PB83-181826

Drinking Water Cost Equations

(U.S.) Municipal Environmental Research Lab.
Cincinnati, OH

Dec 82

U.S. Department of Commerce
National Technical Information Service
NTIS

EPA-600/2-82-055
December 1982

PB83-181826

DRINKING WATER COST EQUATIONS

by

Paul Dorsey

and

Robert M. Clark

Drinking Water Research Division
Municipal Environmental Research Laboratory
Cincinnati, OH 45268

MUNICIPAL ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OH 45268

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/2-82-055	2. ORD Report	3. RECIPIENT'S ACCESSION NO. PB83 181826
4. TITLE AND SUBTITLE Drinking Water Cost Equations		5. REPORT DATE December 1982 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Paul Dorsey and Robert M. Clark		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Drinking Water Research Division Municipal Environmental Research Laboratory 26 West St. Clair St., Cincinnati, Ohio 45268		10. PROGRAM ELEMENT NO. PE - BNC1A 11. CONTRACT/GRANT NO. In-House
12. SPONSORING AGENCY NAME AND ADDRESS Municipal Environmental Research Laboratory - Cin., OH Office of Research and Development U.S. Environmental Protection Agency Cincinnati, Ohio 45268		13. TYPE OF REPORT AND PERIOD COVERED Final July 1980 - Sept. 1981 14. SPONSORING AGENCY CODE EPA / 600/ 14

15. SUPPLEMENTARY NOTES

Project Officer - Robert M. Clark (513) 684-7488

16. ABSTRACT

This report presents capital, and operating and maintenance cost equations for 99 water treatment unit processes. The equations, derived from a cost data base developed fro the Drinking Water Research Division can be used to provide preliminary cost estimates fro individual unit processes or for entire trains.

Methodology used for deriving the equations, an explanation as to how the equations were developed, equation testing, possible uses, and examples of their application are presented in this report. A computer program has been developed to encourage use of these equations.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Economic Analysis; Statistical Analysis; Water Treatment; Valve Engineering	Unit Process; Design; Cost Minimization; Regression Analysis	13B 14A

18. DISTRIBUTION STATEMENT Release to Public	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES 155
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE

NOTICE

THIS DOCUMENT HAS BEEN REPRODUCED FROM THE BEST COPY FURNISHED US BY THE SPONSORING AGENCY. ALTHOUGH IT IS RECOGNIZED THAT CERTAIN PORTIONS ARE ILLEGIBLE, IT IS BEING RELEASED IN THE INTEREST OF MAKING AVAILABLE AS MUCH INFORMATION AS POSSIBLE.

NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

FOREWORD

The U.S. Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimonies to the deterioration of our natural environment. The complexity of that environment and the interplay of its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution, and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems to prevent, treat, and manage wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, to preserve and treat public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research - a most vital communications link between the researcher and the user community.

The cost of water treatment processes that may be used for the removal of contaminants included in the National Interim Primary Drinking Water Regulations is of interest to the U.S. Environmental Protection Agency, State and local agencies, and consulting engineers. The cost equations for the 99 unit process discussed in this report were selected for their ability to remove (either individually or in combination) contaminants included in the National Interim Primary Drinking Water Regulations.

Francis T. Mayo
Director
Municipal Environmental Protection Agency

ABSTRACT

This report presents capital, and operating and maintenance cost equations for 99 water treatment unit processes. The equations, derived from a cost data base developed for the Drinking Water Research Division can be used to provide preliminary cost estimates for individual unit processes or for entire treatment trains.

Methodology used for deriving the equations, an explanation as to how the equations were developed, equation testing, possible uses, and examples of their application are presented in this report. A computer program has been developed to encourage use of these equations.

TYPING GUIDE SHEET

BEGIN FIRST LINE OF TEXT HERE
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD, BEGIN SECTIONS HERE

CONTENTS

Disclaimer ii
Foreword iii
Abstract iv
Acknowledgments. vi

Introduction 1
Need for Pre-Design Estimates. 2
Reliability of Estimates 3
Development of Cost Data 7
Development of Cost Equations. 13
Application of Equations 86
Computer Program 90
Summary and Conclusions. 90
References 93
Appendix A - Computer User's Guide for Cost Equations. 94
Appendix B - Computer User's Guide for Quantity Equations. . . . 142

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS

PAGE NUMBER
TYPING GUIDE SHEET

ACKNOWLEDGMENTS

The authors would like to acknowledge the following individuals for their assistance in preparing this study: Dr. Stephen Shelton and Mr. Mike Montobello of the University of South Carolina; Dr. Arun Deb and Mr. Bill Richards of Roy F. Weston Inc.; and Ms Pat Pierson of MERL-Cincinnati, EPA.

INTRODUCTION

The Safe Drinking Water Act of 1974 emphasizes the need to consider costs when promulgating regulations. Frequently these regulations become translated into generalized design requirements for technology rather than into specific unit process designs. Concern over the cost of regulatory requirements has increased general interest in efficient unit process design, as have, concerns over continuing trends in higher costs for labor, energy, materials, and other important input factors.

To respond to some of this concern over the cost of water supply the Drinking Water Research Division of EPA's Municipal Environmental Research Laboratory sponsored a research effort to develop cost data associated with water supply unit processes.[1] The purpose of the project was to develop operating and capital costs for water treatment processes that are sufficiently accurate for preliminary planning and flexible enough for cost effectiveness studies. Before being considered acceptable, the costs were developed for 99 unit processes by a design consultant and reviewed by a cost-estimating specialist.

This report presents equations derived from the original data and shows how these equations can be used for unit process cost estimating. Examples based on a standard layout for a water supply treatment plant and standard values for the input factors to the cost equations are presented.

NEED FOR PRE-DESIGN ESTIMATES

Although no two treatment plants are alike, one cannot infer that comparisons are meaningless.[2] Although seldom, if ever, are any two plants exactly the same, two plants with similar water treatment goals can be similar and can often be meaningfully compared if adjusted to a common base.

When considering concepts or designs, frequent economic appraisals are necessary to eliminate noncost effective alternatives and to concentrate research and engineering efforts into channels leading to the most attractive end results.[3] These economic appraisals must be made without the benefit of firm estimates based upon detailed design. When some indication of the cost of constructing a plant is required, an individual closely concerned with the development or a specialist with previous estimating experience and a reference file of cost data often prepares an estimate. The dependability of the result and the amount of time spent in developing the necessary data varies widely.

These estimates, broadly termed the "predesign" estimate, are useful for guiding research into examining the most desirable of several process or design alternatives. Only when the choice between alternatives is difficult are complete designs and price quotation needed to select the proper technology.

COST ESTIMATION FOR RESEARCH

Many water treatment processes originate in the laboratory and are tested through field-scale pilot plant studies. When a new process is considered for field-scale evaluation, the question of the cost of this process in full scale application arises. The data presented in this paper can be used to answer this question. By disclosing the most costly features of the process, a cost estimate may suggest some specific areas for further study.

PRELIMINARY ENGINEERING

Preliminary engineering to translate laboratory and pilot plant data into equipment design, piping, layout, buildings, etc. can start as soon as a project appears attractive.[4] The first step should be a detailed process flow sheet with complete material and energy balances.

Preliminary selection of types and sizes of equipment can be made from the flow sheet. In some cases the most favorable equipment can be choosen by comparing purchase prices of equipment performing the same function. In other cases the direct operating and installed costs of competitive equipment must be considered. Simple formulas can be developed to assist in making these comparisons. Examples of such formulas and their applications appear later in this report.

Before preliminary engineering can be completed and construction can be started, all decisions must have been made between competitive processes, raw materials, plant sites, scale of production, etc. Cost considerations are extremely important in these choices. Simple factors will dictate most fundamental decisions; but somewhere in the selection process may be a choice between two courses of action in which nearly all factors must be considered in a "full-scale" estimate.

Cost estimates have their greatest utility for these kinds of decisions. In other words, after all other factors are considered, the final choice of unit processes should be based on the the most economically attractive alternatives. The considerations involved are nearly the same as those for evaluating the desirability of construction.

APPROVAL OF CONSTRUCTION

In the final analysis, the decision of whether to build a treatment facility involves many factors that must be weighed judgmentally:

1. total capital outlay,
2. estimated operating costs,
3. terminal production costs,
4. amount of water to be produced per year,
5. quality specifications required,
6. processes to be used,
7. amount of waste generated,
8. location of the plant, and
9. support facilities required.

Many times misunderstandings in comparative costs can be eliminated by following the steps outlined above. For example, two treatment plants, one with sludge handling facilities and one without, can have quite different costs.[5]

Understanding which design variables have the greatest impact on cost is often important. The equations presented in this report can therefore frequently be used to perform sensitivity tests.[6]

RELIABILITY OF ESTIMATES

The factors affecting the reliability of cost estimates include availability of basic data, state of development, definition of scope, the time expended on analysis, and experience of the analyst. Figure 1 illustrates the effect these factors can have on capital costs for projected and actual facilities. These same factors apply to estimating operating costs as well.[7]

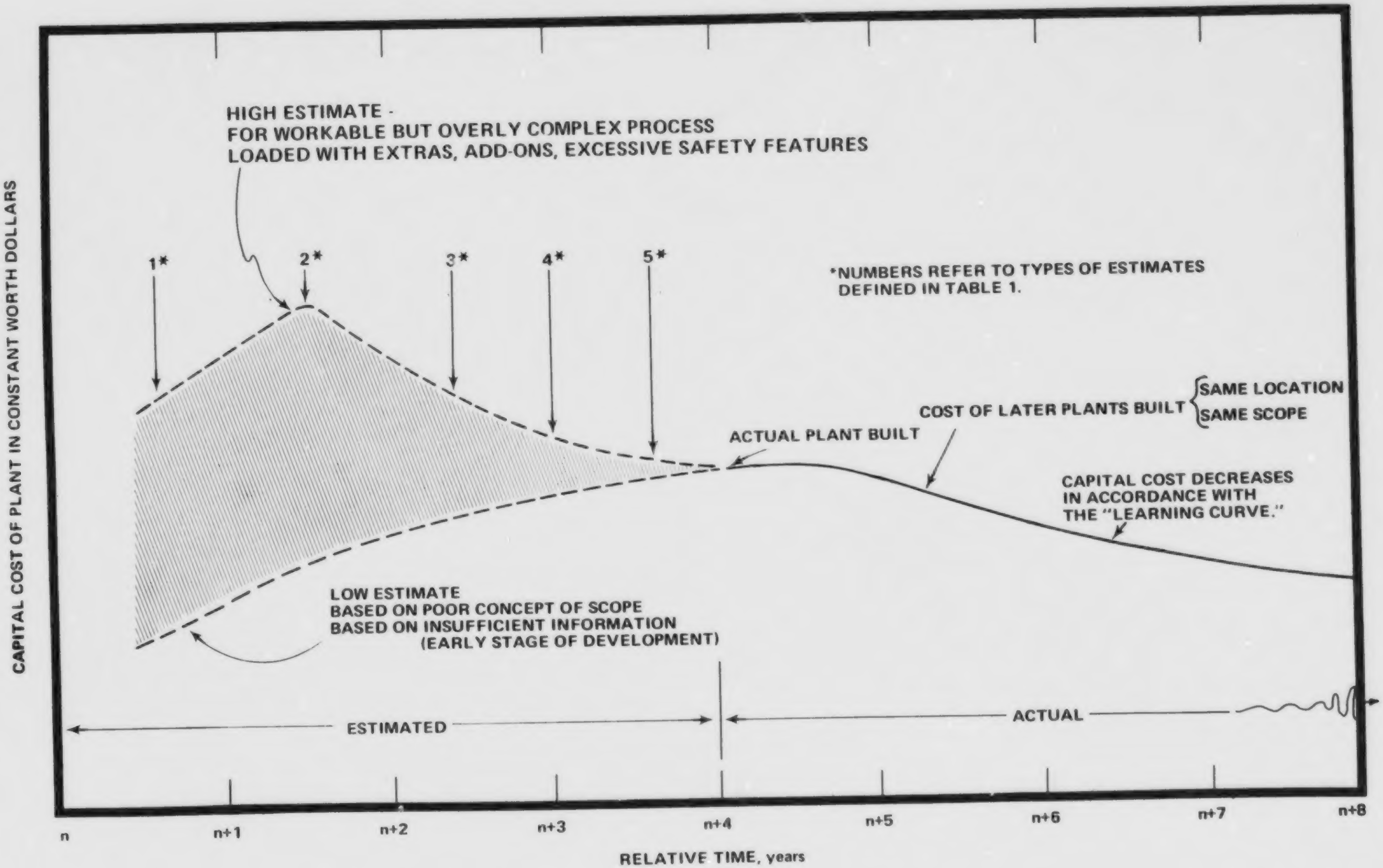


Figure 1. Effect of various factors on projected and actual capital costs.

Table 1 summarizes the characteristics, purpose and reliability of five basic types of cost estimates.

1. Order-of-Magnitude Estimates

Rapid, but approximate order-of-magnitude estimates are useful for a "ball park" figure early in a study; later they can provide a check on results obtained from a more detailed method.

2. Study Estimates

Study estimates follow a variety of schemes depending on the form of the cost data; specific methods may be identified with a given type of technology.

3. Preliminary Estimates

Preliminary estimates require the individual, independent estimation of each item. A preliminary estimate is made either when a higher degree of accuracy then attainable by the study estimate is sought or when the cost data are not available in a form to permit a study estimate to be readily executed.

4. Definitive Estimates

Definitive estimates call for detailed information from an engineering design because they are costly to prepare. Definitive estimates should not be made unless construction is contemplated or detailed engineering information is available.

5. Detailed Estimates

Detailed estimates call for complete survey specifications and working drawings. The purpose is to control the cost of the project being built and is for site specific installations.

TABLE 1. DEFINITION OF FIVE BASIC TYPES OF ESTIMATES OF TOTAL PLANT COST[7]

Estimate type (Each has several designations)	Characteristics	Purpose	Usual Reliability
1. Order-of-magnitude ratio	Rapid. Very rough.	Preliminary indication. Check on result by more detailed method.	About + 30% to -60%
2. Study (commonly a so-called factor estimate)	Flow diagram, material and energy balance, type and size equipment.	For generalized evaluations. Guidance for further investigation. Basis for process selection. R&D guidance.	± 30%
3. Preliminary budget authorization	In addition to above, surveys and some engineering of foundations, transportation facilities, buildings, structures, lighting, etc.	Basis for decision to undertake detailed engineering. Sometimes basis for budget authorization. Can be for generalized evaluation, but usually for site specific installation.	± 20%
4. Definitive project control	More detailed engineering, but usually short of complete specifications and working drawings. Requires exerienced estimating organization and substantial outlay.	Sometimes the basis for budget authorization. Provides improved estimate of project to be built. For site specific installations.	± 10%
5. Detailed firm contractor's	Complete site surveys, specifications, working drawings.	Made to control cost of project being built. For site specific installations.	± 5%

DEVELOPMENT OF COST DATA

Data for this study were dervied from a carefully designed research study to establish water supply unit process cost curves on a consistent and understandable basis.[1] The study focused on (1) processes for removing from potable water those contaminants included in the National Interim Primary Drinking Water Regulations (NIPDWR) and (2) on development of construction and operation and maintenance cost curves for these processes. The final data base contained cost curves for 99 unit processes and a computer program for retrieving, updating and combining the cost data.[8] Characteristics of these data are described in the following sections.

DERIVATION OF COST CURVES

The construction cost for each unit process considered in the original research project is presented as a function of the process design parameter that was determined to be the most useful and flexible under varying conditions. Variables such as loading rate, detention time, or other conditions that can vary because of designer's preference or regulatory agency requirements were used. For example, granular activated carbon (GAC), concrete contactor construction cost curves are presented in terms of cubic feet of contactor volume; this approach allows various empty bed contact times to be evaluated. Contactor operation and maintenance cost curves are presented in terms of square feet of surface area because operation and maintenance requirements are more appropriately related to surface area than to contactor volume. Reactivation facility cost curves are presented in terms of square feet of hearth area for the multiple hearth furnace and pounds per day of reactivation capacity for the other reactivation technologies considered. This approach provides greater flexibility in the use of the cost curves than if the costs were related to water flow through the treatment plant. Figures 2 and 3 show typical construction cost curves and some of the operating and maintenance cost components for pressure carbon contactors. A feature common to many of the curves is a decrease in slope of the curve at smaller size ranges; Figure 3 illustrates this effect. This feature is significant in deriving the equations to be discussed later.

METHODS USED TO DEVELOP COST CURVES

The construction cost curves were developed with the use of equipment cost data supplied by manufacturers, cost data from actual plant construction, unit takeoffs from actual and conceptual designs, and published data. An approach similar to that which would be utilized by a general contractor in determining a construction bid was then used to check these cost curves. Any discrepancies that existed between the initial estimate and the second estimate were then resolved.

CONSTRUCTION COST COMPONENTS

The costs for eight principal construction components were developed and, then aggregated to give the construction cost for each unit process.

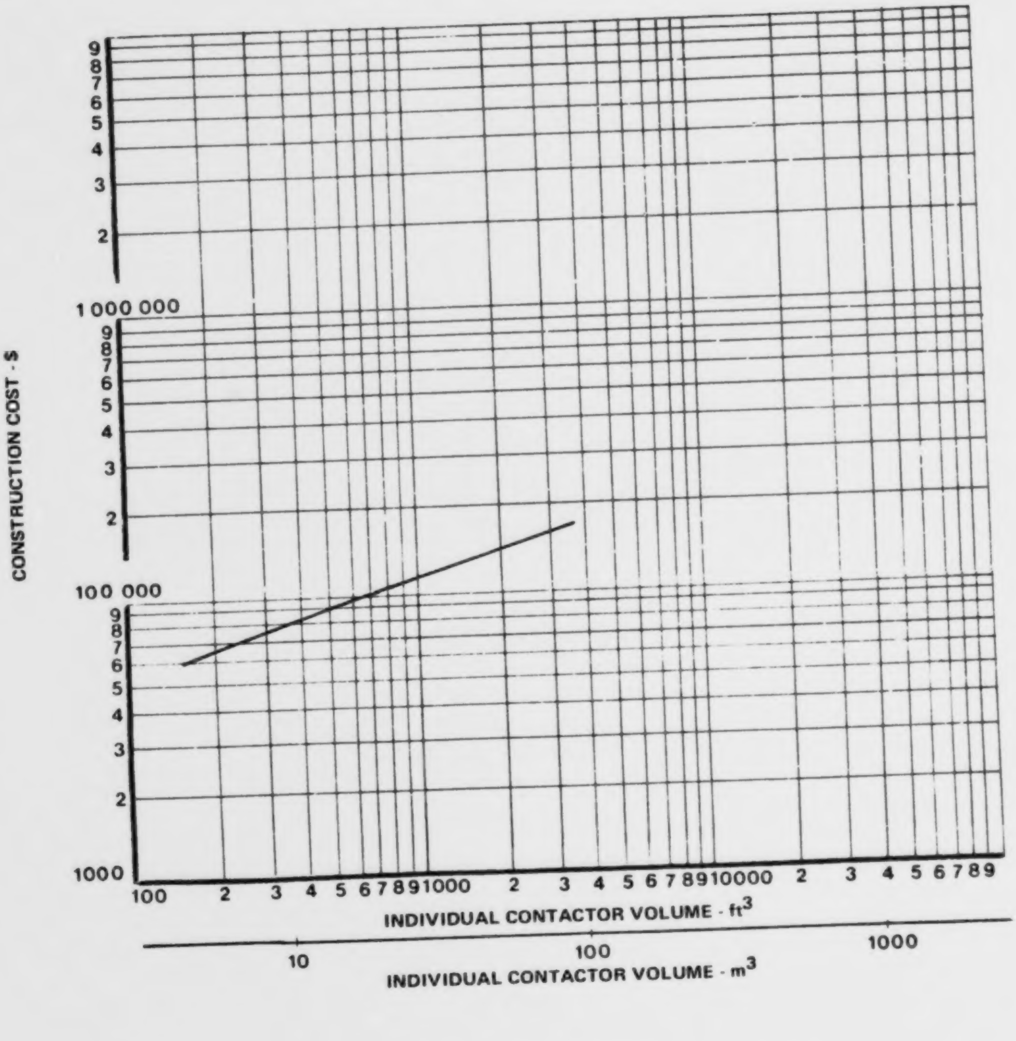


Figure 2. Construction cost for pressure carbon contactors.

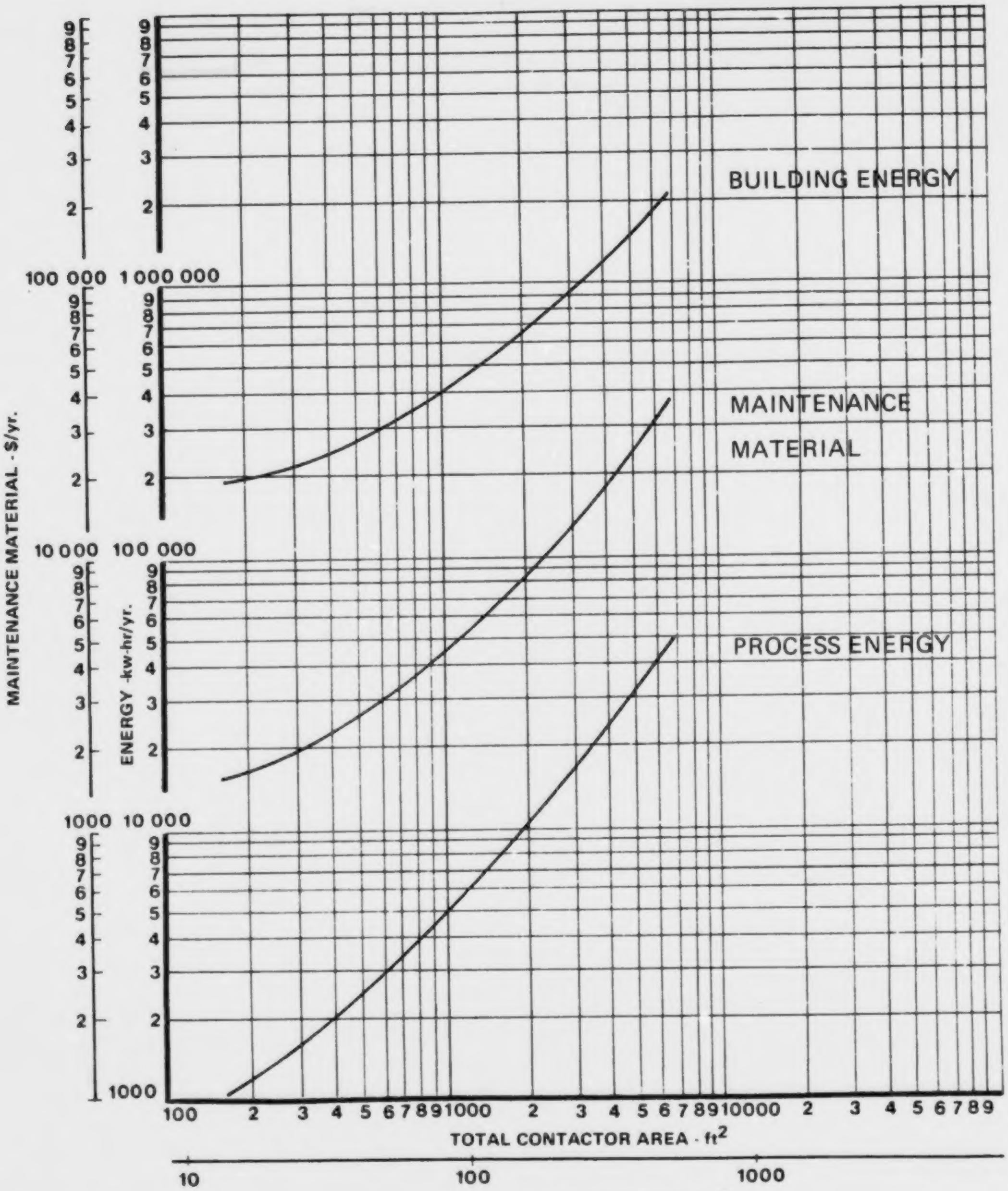


Figure 3. Operation and maintenance requirements for pressure carbon contactors - building energy and maintenance material process energy.

The eight components are (1) excavation and sitework, (2) manufactured equipment, (3) concrete, (4) steel, (5) labor, (6) pipe and valves, (7) electrical and instrumentation, and (8) housing. These categories also provide enough detailed information to permit accurate cost updating.

The construction cost curves are not the final capital cost for the unit process because these curves do not include costs for general contractor overhead and profit, administration, engineering and legal fees, fiscal determinations, and interest during construction. These items are more directly related to the total cost of a project than to the cost of the individual unit processes. Therefore, if more than one unit process is required, the overhead costs are more appropriately added after the cost of the individual unit processes are totaled.

OPERATION AND MAINTENANCE COST COMPONENTS

Operation and maintenance requirements were developed for building-related energy, process energy, maintenance material, and labor. The separate determination of building energy allows for regional variations. Energy requirements are presented in kilowatt-hours per year for electricity, standard cubic feet per year for natural gas, and gallons per year for diesel fuel. Labor is presented in hours per year, allowing local variations to be incorporated into the operation and maintenance cost calculations. Maintenance material cost, given in dollars per year, does not include the cost of chemicals. Chemical costs are added separately as shown in later examples.

In the original study, for the majority of the 99 unit processes, three separate graphs were used to present construction and operation and maintenance curves. The first graph presented the construction cost, the second graph presented energy (electrical, natural gas, and diesel fuel) and maintenance material requirements, and the third graph presented labor requirements and total operation and maintenance cost.

UPDATING CONSTRUCTION COST CURVES

For many engineering purposes, a single cost index such as the Engineering News Record (ENR) Construction Cost Index (CCI) can be used to update construction costs. When this approach provides sufficient accuracy, a single index is certainly the simplest and easiest approach. In the case of water treatment construction costs, especially those for carbon treatment, use of the CCI is not always recommended because the construction components used in its development are not related to those required for water treatment plants. For example, the CCI does not include process equipment or electrical equipment for instrumentation and control. For water treatment plants, the use of several other indices is often recommended, for example the Bureau of Labor Statistics (BLS) indices in conjunction with the ENR Building Cost Index and Skilled Labor Wage Index.

Table 2 shows the indices recommended for application to each of the eight construction cost components representing the major items of material and labor affecting the cost of water treatment plant construction. This approach allows updating to be done proportional to changes in the cost of each component. The eight construction cost components represent the major items of material and labor affecting the cost of water treatment plant construction.

TABLE 2. INDICES FOR CONSTRUCTION COSTS

Cost Component	Type of Index	October 1978 Value of Index
Excavation and sitework	ENR Wage Index (Skilled Labor)	247
Manufactured equipment	BLS General Purpose Machinery and Equipment - Code 114	221.3
Concrete	BLS Concrete Ingredients - Code 132	221.1
Steel	BLS Steel Mill Products - Code 1013	262.1
Labor	ENR Wage Index (Skilled Labor)	247
Pipe and valves	BLS Valves & Fittings - Code 11490	236.4
Electrical equipment and instrumentation	BLS Electrical Machinery and Equipment - Code 117	167.5
Housing	ENR Building Cost Index	254.76

The principal disadvantages to using multiple indicies are the lack of geographical specificity of the BLS indices and the additional effort involved in the use of seven additional indices rather than a single index. The approach used to develop the cost data provides the user with a choice of updating procedures: (1) The individual cost indices can be applied to the components, and the component costs can then be added to obtain the unit process cost, (2) As an alternative, the total unit process cost can be updated in a single step by applying the ENR Construction Cost Index to the sum of the eight cost components.

UPDATING OPERATION AND MAINTENANCE COSTS

Operation and maintenance costs are updated somewhat differently than Construction Costs. To update energy and labor costs the prevailing unit costs for energy and labor are used. Maintenance material costs which do not include chemicals, are best updated with the use of the new Producer Price Index for Finished Goods.

DATA MANIPULATION

In the original project a computer program was developed. The computer program and data file that contain the construction costs and operation and maintenance requirements are presented in the C/W/C report. The purpose of the computer program was to allow costs to be retrieved, updated, and analyzed.

A number of other factors can be varied in addition to the indices used for updating: (1) the operating parameter for the process, (2) sitework and interface piping cost, (3) special subsurface requirements, (4) standby power requirements, (5) general contractor's overhead and profit percentage, (6) engineering costs, (7) land cost, (8) legal, fiscal, and administrative costs, and (9) interest during construction and capital cost amortization.

The computer program, written in Fortran, was designed to operate on the PDP-11/70 computer system. Although a compact and efficiently written program, it still requires a relatively large amount of memory and must be compiled on a specific computer before it may be used.

To improve the usefulness of the cost data, a series of analytic equations were developed for each of the unit processes considered in the C/W/C report. The equation development is described in the following sections.

DEVELOPMENT OF COST EQUATIONS

With the use of the cost curves described in the previous sections, regression estimates were calculated based on the general equation form:

$$Y = aX^{b}{}_{2}.....X_{n}{}^{r} \qquad (1)$$

where

Y = annual operating or capital cost

a,b,...,r = constants determined from the regression analysis.

$X_1,X_2,...X_n$ = variables influencing cost such as design capacity, power cost, etc.

With the use of a computer program developed for calculating the original cost data and a random number generator, estimates based on the general equation form above were computed. All capital costs were calculated on the basis of 8% interest and a 20-year amortization period, but conversion to another base requires only a simple calculation. Overhead, interest during construction and engineering fees were calculated from the original curves and, in general, account for approximately 30% of the total capital cost.

The general form of the equations developed are as follows:

$$OM = K_1USRT_o{}^{b}PR^{c}\ PPI^{d}DHR^{e}NTG^{f}DSL^{g}UN^{h}{}_{i}{}^{TDH}{}_{j}{}^{MI}{}_{k}{}^{G} \qquad (2)$$

$$CC = K_2USRT_c{}^{l}CCI^{m}UN^{n}{}_{o}{}^{TDH}{}_{p}{}^{MI}{}_{q}{}^{G} \qquad (3)$$

where

OM = Annual operating and maintenance cost in \$/yr

CC = Annual capital cost in \$/yr based on an 8% interest rate and 20 yr amortization period

$URST_o$ = Design parameter for operating and maintenance cost

$USRT_c$ = Design parameter for capital cost

PR = Power cost in \$/kwhr

PPI = Producers Price Index divided by 100

DHR = Direct hourly wage rate in \$/hr

NTG = Natural gas in \$/scf

DSL = Cost for diesel fuel in \$/gal

UN = Number of units in a process

TDH = Total dynamic head in ft

G = Energy gradient in sec^{-1}

MI = Distance in miles

CCI = Engineering News Record Construction Cost Index divided by 100

$K_1,K_2,a,b,c,d,,, p,q$ = constants estimated from regression analysis

Specific definitions for USRT (design parameter) for the various unit processes considered are contained in Table 3.

TABLE 3. DESIGN PARAMETERS (USRT)

Unit Process	USRT
Cl_2 Feed-Cylinder Storage	lb/day
Cl_2 Feed-on-Site Storage Tank	lb/day
Cl_2 Feed from Rail Car	lb/day
Chlorine Dioxide Generation Feed	lb/day
Ozone Generation Systems	lb/day
Ozone Contact Chamber	cu ft
On-Site Hypochlorite Generation	lb/day
Alum Feed-Liquid Stock	lb/hr
Alum Feed-Dry Stock	lb/hr
Polymer Feed Systems	lb/hr
Lime Feed - No Recalcination	lb/hr
Lime Feed - With Recalcination	lb/hr
Potassium Permanganate	lb/day
Sulfuric Acid Feed System	gpd
Sodium Hydroxide Feed System	lb/hr
Ferrous Sulfate Feed System	lb/hr
Ferric Sulfate	lb/hr
Anhydrous Ammonia Feed Facility	lb/day
Aqua Ammonia Feed Facility	lb/day
Powdered Activated Carbon Feed	lb/hr
Rapid Mix	cu ft
Flocculation	cu ft
Circular Clarifier - Lime Sludge	sq ft
Circular Clarifier - Lime	sq ft
Rectangular Clarifier - Lime Sludge	sq ft
Rectangular Clarifier - FeCl & Alum Sludge	sq ft
Upflow Solids Contact Clarifier	sq ft
Gravity Filtration Structure	sq ft
Tube Settling Modules	sq ft
Filtration Media - Rapid Sand	sq ft
Filtration Media - Dual Media	sq ft
Filtration - Mixed Media	sq ft
Backwash Pumping Facilities	
Capital Cost	gpm
O&M Cost	sq ft
Hydraulic Surface Wash Systems	sq ft
Air-Water Backwash Facilities	sq ft
Wash Water Surge Basins	gal
Filter Modification Rapid Sand to High Rate	sq ft
Continuous Auto Backwash Filter	sq ft

TABLE 3. DESIGN PARAMETERS (USRT) (Cont'd)

Unit Process	USRT
Recarbonation Basin	cu ft
Recarbonation-Liquid CO_2 Feed	lb/day
Recarbonation-CO_2 From Submerged Burner	lb/day
Recarbonation-CO_2 From Stack Gas	lb/day
Multiple Hearth Recalcination	sq ft
Contact Basin - Direct Filtration	cu ft
Pressure Diatomite Filter	mgd
Vacuum Diatomite Filters	mgd
Pressure Filtration Plants	sq ft
In-Plant Pumping	mgd
Wash Water Storage Tanks	gal
Reverse Osmosis	mgd
Pressure Ion Exchange-Softening	mgd
Gravity Ion Exchange-Softening	mgd
Pressure Ion Exchange-NO3 Removal	mgd
Activated Alumina-Fluoride Removal	mgd
Gravity GAC Contactors-Concrete	cu ft
Gravity Contactors-Steel	cu ft
Pressure Carbon Contactors	
Capital Cost	cu ft
O&M Cost	sq ft
Convert Filter to GAC Contactor	sq ft
Granular Activated Carbon-Construction Cost	lb
Makeup Carbon-Cost - O&M Only	lb/yr
Capping Sand Filter w/Anthracite	sq ft
Regional GAC Regeneration-Transportation & Storage	
Capital Cost	cu ft
O&M Cost	lb/yr
Regional Multi Hearth GAC Regeneration	sq ft
Multiple Hearth GAC Regeneration	sq ft
Infrared Carbon Regeneration Furnace	lb/day
Fluidized Bed GAC Regeneration	lb/day
Powdered Carbonation Regeneration-Fluidized Bed	lb/day
Powdered Carbonation Regeneration-Atomized	lb/day
Chemical Sludge Pumping-Thickened	gpm
Gravity Sludge Thickener - Lime	sq ft
Gravity Sludge Thickener - Alum and FeCl	sq ft
Vacuum Filters	sq ft
Belt Filter Press	gpm
Filter Press	cu ft
Decanter Centrifuges	gpm
Basket Centrifuges	gpd
Sand Drying Beds	sq ft

TABLE 3. DESIGN PARAMETERS (URST) (Cont'd)

Unit Process	USRT
Sludge Dewatering Lagoons	
Capital Cost	cu ft
O&M Cost	cu ft/yr
Sludge Disposal-Sanitary Sewer	gpm
Liquid Sludge Hauling	mg/yr
Dewatering Sludge Hauling	cy/yr
Raw Watering Pumping Facility	mgd
Finished Water Pumping Facility	mgd
Clearwell Storage-Below Ground	gal
Clearwell Storage-Ground level	gal
Diffused Aeration Basin	cu ft
Aeration-Aeration Basin	cu ft
Administrative, Laboratory, & Maintenance Building	mgd

TYPING GUIDE SHEET

Equations (2) and (3), are compact; they allow a direct analysis of the sensitivity of cost to certain variables and can be used for optimization. To estimate the equation parameters a set of random numbers spanning the range of the input variables for a given cost curve were generated. These randomly generated input values were used to generate a cost. After this procedure was repeated 100 times for a given variable range, the randomly generated cost values were regressed against the randomized input values using the form of Equations (2) and (3). The result was a continuous analytic equation that, in effect, simulated the cost data file.

The following four steps summarize development of the cost equations:

(1) a uniform, distributed-function, random number generator was initiated;

(2) a series of intermediate computer programs that arranged data in the input data files was executed;

(3) costs were generated from the Culp Fortran program within specified boundaries;

(4) statistical analysis was done using the cost and input variables to derive a final equation;

(5) all capital costs were calculated at 8% interest and a 20-yr amortization period.

Not all of the parameters were significant for some of the equations. After each equation was developed, it was checked against the original data.

For many of the cost curves (as shown in Figure 3), the cost curve changes slope at lower levels of the design parameter. This phenomenon is a reflection of economies of scale, and the limitation is inherent in sizing technological components. Below a given use level, the size of a component often remains constant, therefore the cost curve no longer changes with the level of the design parameter. Separate "small size" cost equations were derived for those unit processes where this occurs.

In order to maintain a consistent curve fit when making the transition from a small system equation to a large system equation slight adjustments were needed to eliminate inconsistencies at the intersection of the equations. This involved either a decrease or increase in the small system or large system equation constant. Figure 4 illustrates the problem that occurs when attempting to fit a single curve with two equations. In most cases the discontinuity from one curve to the next is relatively insignificant in terms of the entire cost spectrum but would cause cost inconsistencies at the intersection of the two curves.

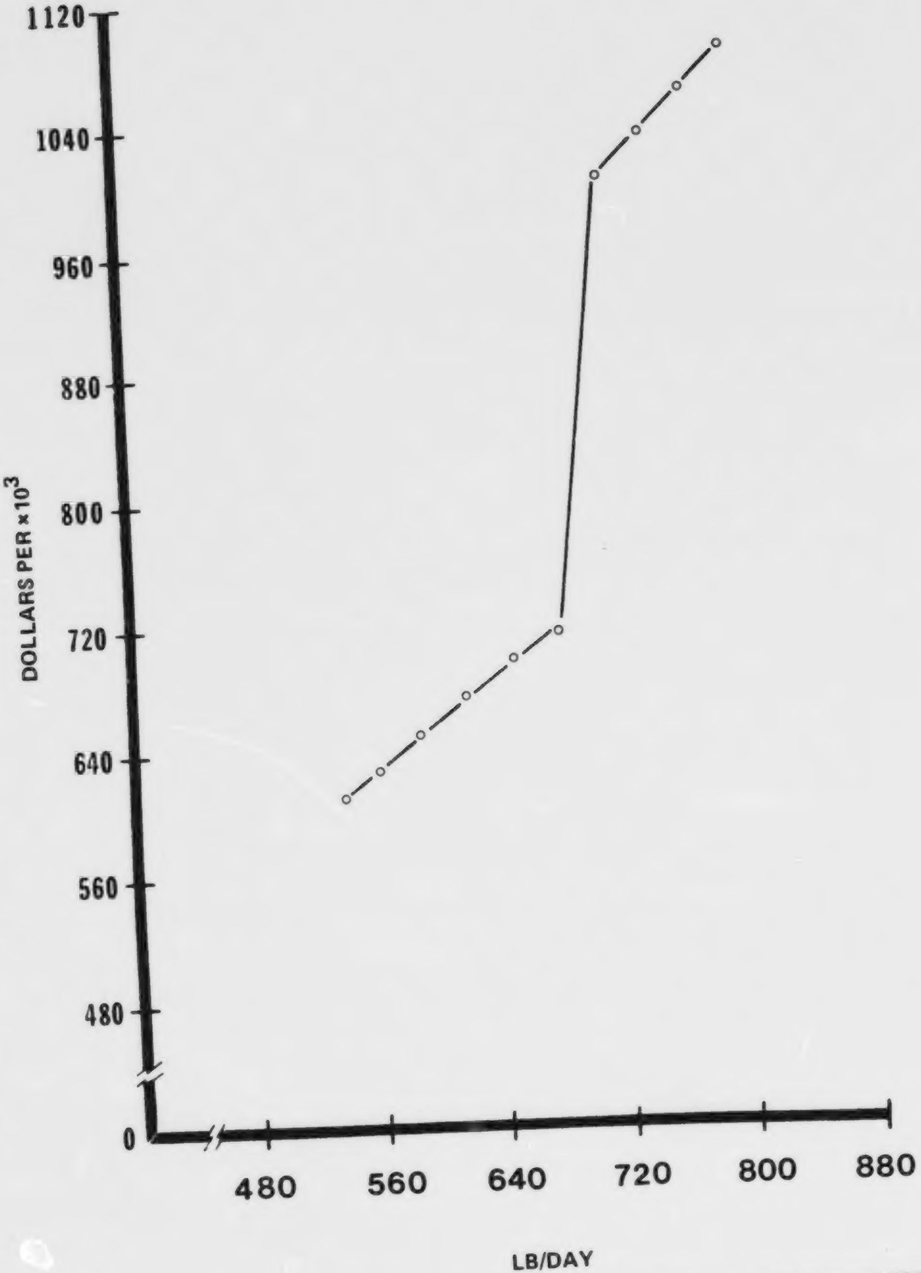


FIGURE 4. CAPITAL COST FUNCTION BEFORE CONSTANT ADJUSTMENT.

While adjusting the constants for the large or small system equations, a check was maintained as to the overall curvefit. In some cases, the overall fit was actually improved.

Figure 4 shows the curve fit for the Ozone Generation Feed System Capital Cost equation. A discontinuity occurs at the transition point between the small system and the large system equations. The original Ozone Generation capital cost equations were:

- $CC = 753.58\ USRT^{.581}\ CCI^{1.0068}$ for $(10<USRT<700)$ lb/day
- $CC = 1324.62\ USRT^{.5454}\ CCI^{1.004}$ for $(700<USRT<3500)$ lb/day

Experimentation found that the best match was accomplished by increasing the constant in the lower range equation to 768.65. The discontinuity was eliminated without huring the equations integrity. Figure 5 illustrates the results of eliminating discontinuity.

This same procedure was followed for all of the equations. Tables 4, 5, 6 and 7 contain these adjusted equations. Tables 4 and 6 contain the "small" size equations and Tables 5 and 7 contain the "large" equations. The parameters shown in Tables 4 through 7 are those generated from the regression analyses but the calculated costs are good to approximately three significant figures.

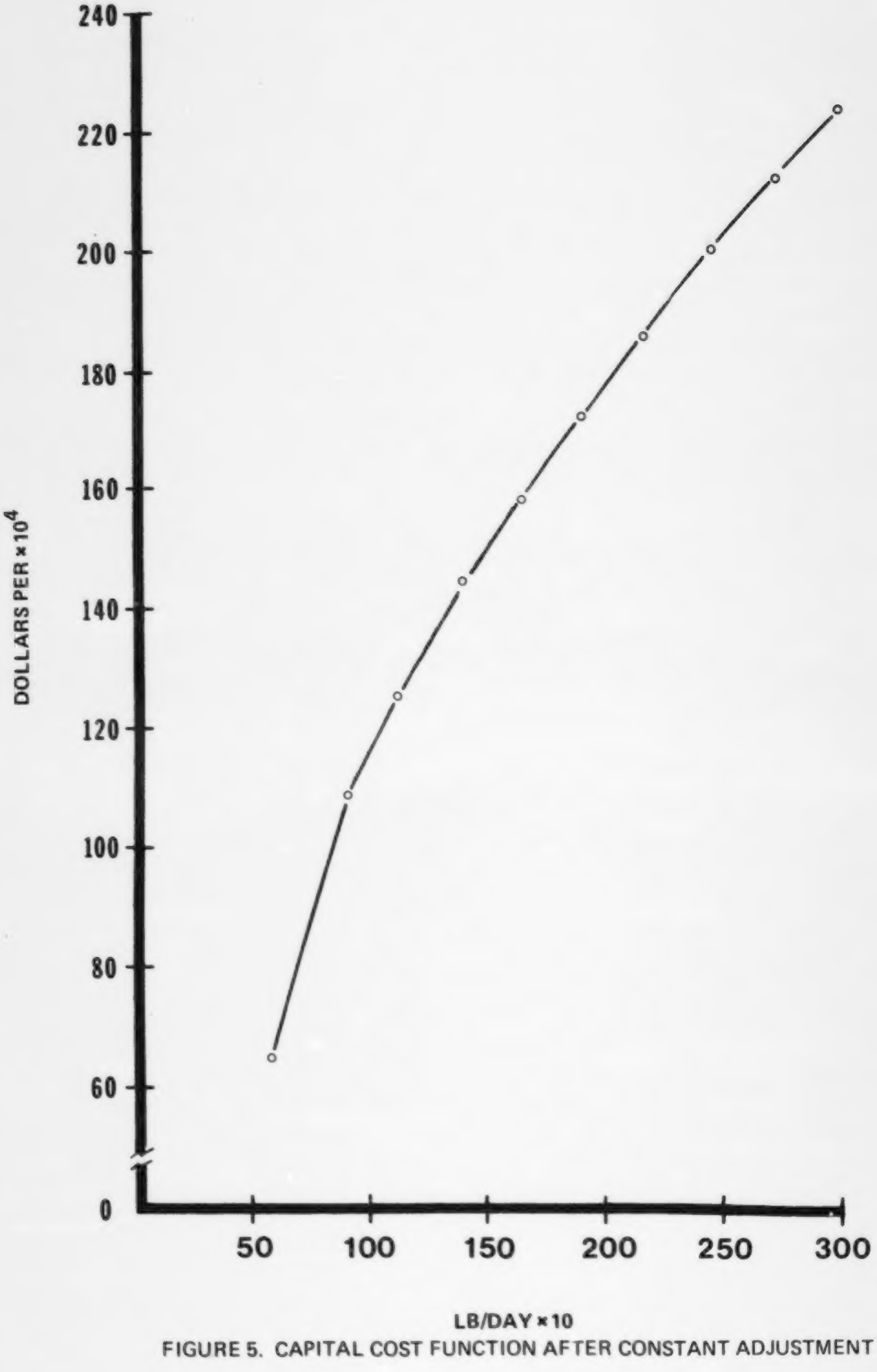


FIGURE 5. CAPITAL COST FUNCTION AFTER CONSTANT ADJUSTMENT

TABLE 4. CAPITAL COST EQUATIONS FOR SMALL RANGE

$$CC = K_2\ USRT^{1}\ CCI^{m}\ UN^{n}\ o^{TDH}\ p^{MI}\ q^{G}$$

PROCESS NAME	USRT RANGE	K_2	1	m	n	o	p	q
Chlorine Feed Cylinder Storage	10-1000 lb/day	157.27	.495	.987	-	-	-	-
Chlorine Feed On Site Storage	2000-10,000 lb/day	90.6	.5782	1.003	-	-	-	-
Chlorine Feed Rail Car	2000-10,000 lb/day	1035.48	.262	.991	-	-	-	-
Chlorine Dioxide Generation, Feed	10-500 lb/day	783.07	.277	.993	-	-	-	-
Ozone Generation Systems	10-700 lb/day	768.65	.581	1.0068	-	-	-	-
Ozone Contact Chamber	400-46,000 ft^3	15.55	.538	.932	-	-	-	-
On-Site Hypochl. Generation	10-750 lb/day	66.63	.815	.998	-	-	-	-
Alum Feed Liquid Stock	5.4-100 lb/hr	753.27	.177	.993	-	-	-	-

TABLE 4. CAPITAL COST EQUATIONS FOR SMALL RANGE (Cont'd)

$$CC = K_2 \ USRT^l \ CCI^m \ UN^n \ o^{TDH} \ p^{MI} \ q^G$$

PROCESS NAME	USRT RANGE	K_2	l	m	n	o	p	q
Alum Feed- Dry Stock	10-100 lb/hr	709.33	.2177	.994	-	-	-	-
Polymer Feed System	1-10 lb/day	949.92	0.0	.998	-	-	-	-
Lime Feed- With Recalcination	1000-10,000 lb/hr	663.6	.236	.994	-	-	-	-
Lime Feed- No Recalcination	10-10000 lb/hr	1532.75	.188	.995	-	-	-	-
Potassium Permanganate, Feed	1-10 lb/day	435.7	.1295	.998	-	-	-	-
Sulfuric Acid Feed	10-100 gpd	300.	.10155	.997	-	-	-	-
Sodium Hydroxide Feed Systems	10-1000 lb/day	673.33	.082	.995	-	-	-	-
Ferrous Sulfate Feed Systems	10-400 lb/hr	692.66	.2045	.9941	-	-	-	-

TABLE 4. CAPITAL COST EQUATIONS FOR SMALL RANGE (Cont'd)

$CC = K_2\ USRT^{l}\ CCI^{m}\ UN^{n}\ o^{TDH}\ p^{MI}\ q^{G}$

PROCESS NAME	USRT RANGE	K_2	l	m	n	o	p	q
Ferric Sulfate Feed System	10-400 lb/hr	285.99	.389	.987	-	-	-	-
Anhydrous Ammonia Feed, Facility	250-5000 lb/day	217.89	.391	1.0	-	-	-	-
Aqua Ammonia Feed Facility	250-5000 lb/day	63.09	.431	.999	-	-	-	-
Powdered Activated Carbon, Feed	3.5-100 lb/hr	2552.	.1578	.9952	-	-	-	-
Rapid Mix	100-1000 ft^3	180.18	.27056	.9927	-	-	-	1.0004375
Flocculation Vertical	1800-25,000 ft^3	23.63	.581	1.0086	-	-	-	-
Flocculation Horizontal	1800-10,000 ft^3	97.97	.39166	.9947	-	-	-	1.001544
Circular Clarifier-Lime	707-1000 ft^2	473.82	.34	.9998	-	-	-	-

TABLE 4. CAPITAL COST EQUATIONS FOR SMALL RANGE (Cont'd)

$$CC = K_2\ USRT^{l}\ CCI^{m}\ UN^{n}\ o^{TDH}\ p^{MI}\ q^{G}$$

PROCESS NAME	USRT RANGE	K_2	l	m	n	o	p	q
Circular Clarifier-Fe and Alum	707-1000 ft^2	473.82	.340	.9998	-	-	-	-
Rectangular Clarifier-Lime	240-4800 ft^2	36.09	.701	.993	1.00047	-	-	-
Rectangular Clarifer- Fe and Alum	240-4800 ft^2	36.09	.701	.993	1.00047	-	-	-
Upflow Solid Contact Clarifier	255-14,500 ft^2	186.7	.5117	1.009	1.0	-	-	-
Tube Settling Modules	280-56,000 ft^2	2.9324	.9087	1.001	-	-	-	-
Gravity Filtration	140-5000 ft^2	456.92	.5787	.9937	-	-	-	-
Filtration Media Rapid Sand	350-3500 ft^2	4.00	.732	.993	-	-	-	-

TABLE 4. CAPITAL COST EQUATIONS FOR SMALL RANGE (Cont'd)

$$CC = K_2\ USRT^1\ CCI^m\ UN^n\ o^{TDH}\ p^{MI}\ q^G$$

PROCESS NAME	USRT RANGE	K_2	1	m	n	o	p	q
Filtration Media-Dual	140-2000 ft^2	8.06	.741	.995	-	-	-	-
Filtration Media Mixed	140-1000 ft^2	13.083	.720	.9945	-	-	-	-
Backwash Pumping Facilities	1260-28,000 gpm	29.95	.590	.966	-	-	-	-
Hydraulic Surface Wash	140-700 ft^2	284.13	.284	.9959	-	-	-	-
Air Water Backwash Fac.	140-600 ft^2	1447.84	.1619	.998	-	-	-	-
Wash Water Surge Basin	10,000-100,000 gal	2.70	.723	1.00156	-	-	-	-
Filter Mod. Rapid Sand to High Rate	100-28,000 ft^2	31.08	.656	.984	-	-	-	-
Continuous Auto Backwash Filter	360-3000 ft^2	279.7	.603	.991	-	-	-	-

TABLE 4. CAPITAL COST EQUATIONS FOR SMALL RANGE (Cont'd)

$$CC = K_2 \, USRT^{1} \, CCI^{m} \, UN^{n} \, o^{TDH} \, p^{MI} \, q^{G}$$

PROCESS NAME	USRT RANGE	K_2	1	m	n	o	p	q
Recarbonation Basin	770-35,200 ft^3	4.467	.6542	.9914	1.002	-	-	-
Recarbonation Liquid -CO2	380-1500 lb/day	774.94	.205	.9994	-	-	-	-
Recarbonation CO2 from Submerged Burn.	500-8000 lb/day	1969.66	.0874	.9997	1.0	-	-	-
Recarbonation CO2 From Stack Gas	2500-10,000 lb/day	10.3008	.668	1.00161	-	-	-	-
Multiple Hearth Recalcination	179-2930 ft^2	5445.06	.436	1.006	1.001	-	-	-
Contact Basin Direct Filtration	2640-52,800 ft^2	9.98	.589	.999	1.001	-	-	-
Pressure Diatomite Filter	1.0-5.0 mgd	13,406.95	.482	.994	-	-	-	-
Vacuum Filtration Diatomite	1-200 mgd	5895.49	.977	.9988	-	-	-	-

TABLE 4. CAPITAL COST EQUATIONS FOR SMALL RANGE (Cont'd)

$$CC = K_2\ USRT^{l}\ CCI^{m}\ UN^{n}\ o^{TDH}\ p^{MI}\ q^{G}$$

PROCESS NAME	USRT RANGE	K_2	l	m	n	o	p	q
Pressure Filtration Plants	100-1400 ft^2	2329.38	.3292	.9926	-	-	-	-
In-Plant Pumping	1-10 mgd	1274.71	.4911	.9112	-	-	-	-
Wash Water Storage	21,000-900,000 gal	.113	.848	.993	-	-	-	-
Reverse Osmosis	1-200 mgd	40564.	.889	.998	-	-	-	-
Pressure Ion Exchange Softening	1-123 mgd	5372.24	.989	1.005	-	-	-	-
Gravity Ion Exchange	2-150 mgd	5916.65	.854	.999	-	-	-	-
Pressure Ion Exchange Nitrate Removal	1.1-12.3 mgd	9596.26	1.047	.9972	-	-	-	-
Activated Alumina Flouride Rem.	.7-135 mgd	3491.	1.007	1.0025	-	-	-	-

TABLE 4. CAPITAL COST EQUATIONS FOR SMALL RANGE (Cont'd)

$$CC = K_2\ USRT^{l}\ CCI^{m}\ UN^{n}\ o^{TDH}\ p^{MI}\ q^{G}$$

PROCESS NAME	USRT RANGE	K_2	l	m	n	o	p	q
Gravity GAC Contactors-Concrete	350-20,000 ft^3	472.15	.382	1.0	1.0	-	-	-
Gravity GAC Contactors Steel	6280-14,100 ft^3	5.64	.8466	1.0	1.0	-	-	
Pressure Carbon Contactors	157-2260 ft^3	368.22	.377	1.0	-	-	-	-
Convert Filter to GAC Contactor	370-70,000 ft^2	6.452	.9063	1.0	-	-	-	-
Granular Act. Carbon	10,000-10,000,000 lb	.0543	.9611	1.0034	-	-	-	-
Make-Up Carbon Cost	-	-	-	-	-	-	-	-
Capping Sand Filter w/anthracite	350-70,000 ft^2	.383	.9818	.9994	-	-	-	-
Regional GAC Regeneration Trans. & Stor.	1000-20,000 ft^3	.880	1.02	1.007	-	-	-	-

TABLE 4. CAPITAL COST EQUATIONS FOR SMALL RANGE (Cont'd)

$$CC = K_2\ USRT^{l}\ CCI^{m}\ UN^{n}\ o^{TDH}\ p^{MI}\ q^{G}$$

PROCESS NAME	USRT RANGE	K_2	l	m	n	o	p	q
Regional Multi-* Hearth GAC Regen.	27-1510 ft^2	60.02	.439	1.0056	1.002	.9995	-	-
Multi-Hearth GAC Regneration	27-1510 ft^2	6047.	.439	1.006	1.002	-	-	-
Infrared Carbon Regen. Furnace	2400-60,000 lb/day	101.5	.607	.9883	-	-	-	-
Fluidized Bed GAC Regeneration	6000-24,000 lb/day	6790.79	.2282	.999	1.0	-	-	-
Powdered Carbon Regen.-Fluidized	220-500 lb/day	17214.	.126	.9999	-	-	-	-
Powdered Carbon Regen.-Atomized	1000-10,000 lb/day	50.835	.835	.997	-	-	-	-
Chemical Sludge Pumping-Unthick.	20-100 gpm	1145.9	.0887	.9984	-	-	-	-
Chemical Sludge Pumping Thickened	50-1250 gpm	267.92	.355	1.005	-	-	-	-

*Multiply Equation by the percent of cost allocated to one participant in the regional system.

TABLE 4. CAPITAL COST EQUATIONS FOR SMALL RANGE (Cont'd)

$$CC = K_2\ USRT^{1}\ CCI^{m}\ UN^{n}\ o^{TDH}\ p^{MI}\ q^{G}$$

PROCESS NAME	USRT RANGE	K_2	1	m	n	o	p	q
Gravity Sludge Thickener-Lime	314-17,800 ft^2	142.83	.481	.984	1.004	-	-	-
Gravity Sludge Thickener-FECL3	314-17,800 ft^2	142.83	.481	.984	1.004	-	-	-
Vacuum Filter	9.4-38 ft^2	5692.91	.0875	.9987	-	-	-	-
Belt Filter Press	15-30 gpm	2510.15	.5397	.9988	-	-	-	-
Filter Press	4.3-20 ft^3	8567.81	.200	.9969	-	-	-	-
Decanter Centrifuges	10-500 gpm	2742.96	.387	.998	1.001	-	-	-
Basket Centrifuges	3600-36,000 gpd	3622.26	.084	.9965	-	-	-	-
Sand Drying Beds	5000-100,000 ft^2	.763	.862	1.0162	-	-	-	-
Sludge Dewater. Lagoons	10,000-350,000 ft^3	.50	.648	.9917	-	-	-	-
Sludge Disposal Sanitary-Sewer	-	-	-	-	-	-	-	-

TABLE 4. CAPITAL COST EQUATIONS FOR SMALL RANGE (Cont'd)

$$CC = K_2\ USRT^1\ CCI^m\ UN^n\ o^{TDH}\ p^{MI}\ q^G$$

PROCESS NAME	USRT RANGE	K_2	1	m	n	o	p	q
Liquid Sludge Hauling	1.25-20 mg/yr	1827.76	.460	.9877	-	-	1.02188	-
Dewatered Sludge Hauling	1000-20,000 cy/yr	1297.15	.1026	.99677	-	-	1.0	-
Raw Water Pumping Fac.	1-10 mgd	921.16	.46477	.991	-	1.0027669	-	-
Finished Water Pumping Fac.	1.0-10 mgd	982.99	.4705	.993	-	1.002813	-	-
Clearwell Below-Ground	10,000-50,000 gal	166.13	.263	.996	-	-	-	-
Clearwell Ground-Level	8500-200,000 gal	54.12	.341	.988	-	-	-	-
Diffused Aeration Basin	1900-380,000 ft^3	15.48	.774	.993	-	-	-	-
Aeration Aeration-Towers	640-256,000 ft^3	11.59	.7199	.9965	-	-	-	-
Administration Building & Lab	1-20 mgd	1164.49	.5707	.9926	-			

TABLE 5. CAPITAL COST EQUATIONS FOR LARGE RANGE

$$CC = K_2\ USRT^{l}\ CCI^{m}\ UN^{n}\ o^{TDH}\ p^{MI}\ q^{G}$$

PROCESS NAME	USRT RANGE	K_2	l	m	n	o	p	q
Chlorine Feed - Cylinder Storage	1000-10,000 lb/day	125.78	.5398	.998	-	-	-	-
Chlorine Feed - On Site Storage	2000-10,000 lb/day	90.6	.5782	1.003	-	-	-	-
Chlorine Feed - Rail Car	2000-10,000 lb/day	1035.48	.262	.991	-	-	-	-
Chlorine Dioxide Generation, Feed	500-3500 lb/day	239.22	.554	1.0129	-	-	-	-
Ozone Generation Systems	700-3500 lb/day	1324.62	.5454	1.004	-	-	-	-
Ozone Contact Chamber	46,000-92,000 ft^3	11.37	.572	.9836	-	-	-	-
On-Site Hypochlorite Generation	750-10,000 lb/day	532.33	.502	1.015	-	-	-	-
Alum Feed - Liquid Stock	100-5400 lb/hr	114.16	.548	.981	-	-	-	-

TABLE 5. CAPITAL COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$CC = K_2\ USRT^1\ CCI^m\ UN^n\ o^{TDH}\ p^{MI}\ q^G$$

PROCESS NAME	USRT RANGE	K_2	1	m	n	o	p	q
Alum Feed - Dry Stock	100-5000 lb/hr	70.55	.656	.994	-	-	-	-
Polymer Feed System	10-200 lb/day	801.98	.1345	.989	-	-	-	-
Lime Feed - With Recalcination	1000-10,000 lb/hr	663.6	.236	.994	-	-	-	-
Lime Feed - No Recalcination	10-10,000 lb/hr	1532.75	.188	.995	-	-	-	-
Potassium Permanganate Feed	10-5000 lb/day	412.35	.139	.998	-	-	-	-
Sulfuric Acid Feed Systems	100-500 gpd	52.2	.485	.993	-	-	-	-
Sodium Hydroxide Feed Systems	1000-10,000 lb/day	16.93	.600	.9823	-	-	-	-
Ferrous Sulfate Feed Systems	400-5350 lb/hr	49.38	.692	.981	-	-	-	-

TABLE 5. CAPITAL COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$CC = K_2\ USRT^{l}\ CCI^{m}\ UN^{n}\ o^{TDH}\ p^{MI}\ q^{G}$$

PROCESS NAME	USRT RANGE	K_2	l	m	n	o	p	q
Ferric Sulfate Feed System	400-6600 lb/hr	30.67	.729	.977	-	-	-	-
Anhydrous Ammonia Feed Facility	250-5000 lb/day	217.89	.391	1.0	-	-	-	-
Aqua Ammonia Feed Facility	250-5000 lb/day	63.09	.431	.999	-	-	-	-
Powdered Activated Carbon Feed	100-7000 lb/hr	373.18	.557	.998	-	-	-	-
Rapid Mix	1000-20,000 ft^3	3.289	.790	.988	-	-	-	1.0007
Floculation Vertical	1800-25,000 ft^3	23.63	.581	1.0086	-	-	-	-
Flocculation Horizontal	10,000-1,000,000 ft^3	5.57	.6916	.992	-	-	-	1.0038296
Circular Clarifier Lime	1000-31,400 ft_2	36.09	.701	.993	-	-	-	-

TABLE 5. CAPITAL COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$CC = K_2 \; USRT^{l} \; CCI^{m} \; UN^{n} \; o^{TDH} \; p^{MI} \; q^{G}$$

PROCESS NAME	USRT RANGE	K_2	l	m	n	o	p	q
Circular Clarifier-Fe and Alum	1000-31,400 ft^2	36.09	.701	.993	-	-	-	-
Rectangular Clarifier-Lime	240-4800 ft^2	36.09	.701	.993	1.00047	-	-	-
Rectangular Clarifier-Fe and Alum	240-4800 ft^2	36.09	.701	.993	1.00047	-	-	-
Upflow Solids Contact Clarifier	255-14500 ft^2	186.7	.5117	1.009	1.0	-	-	-
Tube Settling Modules	280-56,000 ft^2	2.9324	.9087	1.001	-	-	-	-
Gravity Filtration	5000-28,000 ft^2	275.62	.671	.989	-	-	-	-
Filtration Media Rapid Sand	3500-74,800 ft^2	.7914	.9336	.9962	-	-	-	-

TABLE 5. CAPITAL COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$CC = K_2\ USRT^{l}\ CCI^{m}\ UN^{n}\ o^{TDH}\ p^{MI}\ q^{G}$$

PROCESS NAME	USRT RANGE	K_2	l	m	n	o	p	q
Filtration Media-Dual	1400-29,900 ft^2	3.722	.8352	.991	-	-	-	-
Filtration Media-Mixed	1000-29,900 ft^2	3.677	.887	.994	-	-	-	-
Backwash Pumping Facilities	1260-28,000 gpm	29.95	.590	.966	-	-	-	-
Hydraulic Surface Wash	700-28,000 ft^2	8.64	.801	.982	-	-	-	-
Air Water Backwash Facility	600-28,000 ft^2	193.66	.4862	.990	-	-	-	-
Wash Water Surge Basin	100,000-500,000 gal	308.11	.331	1.0069	-	-	-	-
Filter Mod. Rapid Sand to High Rate	100-28,000 ft^2	31.08	.656	.984	-	-	-	-

TABLE 5. CAPITAL COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$CC = K_2\ USRT^{1}\ CCI^{m}\ UN^{n}\ o^{TDH}\ p^{MI}\ q^{G}$$

PROCESS NAME	USRT RANGE	K_2	1	m	n	o	p	q
Vaccum Diatomite Filter	1-200 mgd	5895.49	.977	.9988	-	-	-	-
Pressure Filtration Plants	1400-28000 ft^2	8.77	1.098	1.0106	-	-	-	-
In - Plant Pumping	10-200 mgd	537.98	.851	.991	-	-	-	-
Wash water Storage	21,000-900,000 gal	.113	.848	.993	-	-	-	-
Reverse Osmosis	1-200 mgd	40564.	.889	.998	-	-	-	-
Pressure Ion Exchange-Softening	1-123 mgd	5372.24	.989	1.005	-	-	-	-
Gravity Ion Exchange	2-150 mgd	5916.65	.854	.999	-	-	-	-
Pressure Ion Exchange Nitrate Removal	1.1-12.3 mgd	9596.26	1.097	.9972	-	-	-	-

TABLE 5. CAPITAL COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$CC = K_2\ USRT^{l}\ CCI^{m}\ UN^{n}\ o^{TDH}\ p^{MI}\ q^{G}$$

PROCESS	USRT RANGE	K_2	l	m	n	o	p	q
Continuous Auto Backwash Filter	3000-70,400 ft^2	11.06	1.005	1.017	-	-	-	-
Recarbonation Basin	770-35,200 ft^3	4.467	.6542	.9914	1.002	-	-	-
Recarbonation-Liquid CO_2	1500-15,000 lb/day	52.42	.5677	.979	-	-	-	-
Recarbonation - CO_2 from Submerged Burner	8000-10,000 lb/day	327.78	.289	.994	.999	-	-	-
Recarbonation - CO_2 From Stack Gas	10,000-50,000 lb/day	116.72	.401	.967	-	-	-	-
Multiple Hearth Recalcination	179 - 2930 ft^2	5445.06	.436	1.006	1.001	-	-	-
Contact Basin Direct Filtration	2640-52,800 ft^3	9.98	.589	.999	1.001	-	-	-
Pressure Diatomite Filter	5-200 mgd	5615.00	.941	1.002	-	-	-	-

TABLE 5. CAPITAL COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$CC = K_2\ USRT^1\ CCI^m\ UN^n\ o^{TDH}\ p^{MI}\ q^G$$

PROCESS NAME	USRT RANGE	K_2	1	m	n	o	p	q
Activated Alumina-Fluoride Removal	.7-135 mgd	3491.	1.007	1.0025	-	-	-	-
Gravity GAC Contactors-Conc.	350-20,000 ft^3	472.15	.382	1.0	1.00	-	-	-
Gravity GAC Contact-Steel	6280-14,100 ft^2	5.64	.8466	1.0	1.00	-	-	-
Pressure Carbon Cont.	157-2260 ft^3	368.22	.377	1.0	-	-	-	-
Convert Filter GAC Cont.	370-70,000 ft^2	6.452	.9063	1.0	-	-	-	-
Granular Activated Carbon	10,000-10,000,000 lb	0.0543	.9611	1.0034	-	-	-	-
Capping Sand Filter w/anth.	350-70,000 ft^2	.383	.9818	.9994	-	-	-	-

TABLE 5. CAPITAL COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$CC = K_2\ USRT^{l}\ CCI^{m}\ UN^{n}\ o^{TDH}\ p^{MI}\ q^{G}$$

PROCESS	USRT RANGE	K_2	l	m	n	o	p	q
Regional GAC Regen. Tran.	1000-20,000 ft^3	.88	1.02	1.007	-	-	-	-
*Regional Multi Hearth GAC Regen.	27-1510 ft^2	60.02	.439	1.0056	.9995	-	-	-
Multi Hearth GAC Regen.	27-1510 ft^2	6047.	.439	1.006	1.002	-	-	-
Infrared Carbon Regen. Furn.	2400-60,000 lb/day	101.5	.607	.9883	-	-	-	-
Fluidized Bed GAC Regen.	6000-24,000 lb/day	6790.79	.2282	.994	1.0	-	-	-
Powdered Carbon Regen. Fluidized	500-33,400 lb/day	1804.4	.4681	.9936	-	-	-	-
Powdered Carbon Regen. Atomized	1000-10,000 lb/day	50.835	.835	.997	-	-	-	-
Chemical Sludge Pumping-Unthick.	100-10,000 gpm	233.24	.4351	1.001	-	-	-	-

*Multiply Equation by the percent of cost allocated to one participant in the regional system.

TABLE 5. CAPITAL COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$CC = K_2\ USRT^{l}\ CCI^{m}\ UN^{n}\ o^{TDH}\ p^{MI}\ q^{G}$$

PROCESS NAME	USRT RANGE	K_2	l	m	n	o	p	q
Chemical Sludge Pumping-Thick.	50-1250 gpm	267.92	.355	1.005	-	-	-	-
Gravity Sludge Thickener-Lime	314-17,800 ft^2	142.83	.481	.984	1.004	-	-	-
Gravity Sludge Tickener-FECL3	314-17,800 ft^2	142.83	.481	.984	1.004	-	-	-
Vacuum Filter	38-1320 ft^2	1202.87	.500	.989	-	-		
Belt Filter Press	30-450 gpm	598.69	.929	.999	-	-	-	-
Filter Press	20-896 ft^3	3941.3	.4573	.9879	-	-	-	-
Decanter Centrifuges	10-500 gpm	2742.96	.387	.998	1.001	-	-	-
Basket Centrifuges	36,000-720,000 gpd	3.764	.7429	.993	-	-	-	-
Sand Drying Beds	100,000-400,000 ft^2	3.95	.7296	1.0093	-	-	-	-

TABLE 5. CAPITAL COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$CC = K_2\ USRT^{l}\ CCI^{m}\ UN^{n}\ o^{TDH}\ p^{MI}\ q^{G}$$

PROCESS NAME	USRT RANGE	K_2	l	m	n	o	p	q
Sludge Dewatering Lagoons	350,000-5,000,000 ft^3	.03207	.860	1.0064	-	-	-	-
Sludge Disposal-Sanitary Sewer	20-10,000 gpm	-	-	-	-	-	-	-
Liquid Sludge Hauling	20-100 MG/Yr	839.89	.730	.9878	-	-	1.03024	-
Dewatered Sludge Hauling	20,000-300,000 cy/yr	6.35	.597	.982	-	-	1.031074	-
Raw Water Pumping Facility	10-200 mgd	305.36	.858	.999	-	1.00492	-	-
Finished Water Pumping Facility	10-300 mgd	300.73	.903	.995	-	1.00263	-	-
Clearwell Storage-Below Ground	50,000-7,500,000 gal	.916	.7334	1.0199	-	-	-	-
Clearwell Storage-Ground Level	200,000-9,400,000 gal	.520	.731	1.016	-	-	-	-

TABLE 5. CAPITAL COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$CC = K_2\ USRT^1\ CCI^m\ UN^n\ o^{TDH}\ p^{MI}\ q^G$$

PROCESS NAME	USRT RANGE	K_2	1	m	n	o	p	q
Diffused Aeration Basin	1900-380,000 ft^3	15.48	.774	.993	-	-	-	-
Aeration-Aeration Towers	640-256,000 ft^3	11.59	.7199	.9965	-	-	-	-
Administration, Building &Lab.	20-200 mgd	1674.25	.4926	1.0093	-	-	-	-

TABLE 6. OPERATING AND MAINTENANCE COST EQUATIONS FOR SMALL RANGE

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Chlorine Feed Cylinder Storage	10-300 lb/day	1506.12	.105	.078	.273	.589	-	-	-	-	-	-
Chlorine Feed-On-Site Storage	2000-10,000 lb/day	430.25	.272	-	.370	.521	-	-	-	-	-	-
Chlorine Feed Rail Car	2000-10,000 lb/day	611.58	.221	.029	.4655	.468	-	-	-	-	-	-
Chlorine Dioxide Generation, Feed	10-100 lb/day	1344.75	0.143	0.065	0.305	.653	-	-	-	-	-	-
Ozone Generation Systems	10-100 lb/day	4844.3	.489	.463	.154	.292	-	-	-	-	-	-
Ozone Contact Chamber	-	-	-	-	-	-	-	-	-	-	-	-
On-Site Hypochl. Generation	10-100 lb/day	1461.94	.362	.263	.197	.452	-	-	-	-	-	-
Alum Feed Liquid Stock	5.4-100 lb/hr	1055.6	.121	.418	.065	.441	-	-	-	-	-	-

TABLE 6. OPERATING AND MAINTENANCE COST EQUATIONS FOR SMALL RANGE (Cont'd)

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Alum Feed-Dry Stock	10-500 lb/hr	369.02	.347	.201	.037	.694	-	-	-	-	-	-
Polymer Feed System	1-200 lb/day	2014.98	.0533	.294	.1037	.537	-	-	-	-	-	-
Lime Feed-With Recalcination	1000-10,000 lb/hr	143.49	.466	.052	.038	.8946	-	-	-	-	-	-
Lime Feed-No Recalcination	10-100 lb/hr	980.42	.2399	.104	.0938	.728	-	-	-	-	-	-
Potassium Permanganate, Feed	1-10 lb/day	401.15	.0488	.078	.035	.858	-	-	-	-	-	-
Sulfuric Acid-Feed	10-500 gpd	76.97	.188	-	-	.8316	-	-	-	-	-	-
Sodium Hydroxide Feed Systems	10-1000 lb/day	389.34	.028	.132	.1027	.717	-	-	-	-	-	-
Ferrous Sulfate Feed Systems	10.7-400 lb/hr.	30.	.823	.136	-	.522	-	-	-	-	-	-

TABLE 6. OPERATING AND MAINTENANCE COST EQUATIONS FOR SMALL RANGE (Cont'd)

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Ferric Sulfate Feed System	13-400 lb/hr	698.41	.158	.1478	-	.704	-	-	-	-	-	-
Anhydrous Ammonia Feed, Facility	250-5000 lb/day	401.86	.3235	.07005	.414	.461	-	-	-	-	-	-
Aqua Ammonia Feed Facility	255-1000 lb/day	112.23	.08977	-	.1273	.854	-	-	-	-	-	-
Powered Activated Carbon, Feed	3.5-350 lb/hr	3198.6	.425	.291	.206	.381	-	-	-	-	-	-
Rapid Mix	100-1000 ft^3	342.5	.3523	.364	-	.581	-	-	-	-	-	1.00129
Flocculation Vertical	1800-25,000 ft^3	21.82	.411	.148	.313	.439	-	-	-	-	-	1.0084
Flocculation Horizontal	1800-30,000 ft^3	17.79	.449	.197	.2936	.435	-	-	-	-	-	1.00916
Circular Clarifier-Lime	707-1590 ft^2	90.17	.253	.092	.182	.682	-	-	1.006	-	-	-

TABLE 6. OPERATING AND MAINTENANCE COST EQUATIONS FOR SMALL RANGE (Cont'd)

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Circular Clarifier-Fe and Alum	707-1590 ft^2	71.18	.260	.064	.189	.709	-	-	1.006	-	-	-
Rectangular Clarifier-Lime	240-600 ft^2	148.04	.184	.057	.156	.747	-	-	1.005	-	-	-
Rectangular Clarifier-Fe and Alum	240-600 ft^2	149.1	.181	.056	.156	.748	-	-	1.005	-	-	-
Upflow Solid Contact Clarifier	255-2500 ft^2	300.76	.261	.155	.134	.654	-	-	1.0052	-	-	1.001959
Tube Settling Modules	-	-	-	-	-	-	-	-	-	-	-	-
Gravity Filtration	140-1000 ft^2	511.22	.479	.236	.111	.589	-	-	-	-	-	-
Filtration Media Rapid Sand	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 6. OPERATING AND MAINTENANCE COST EQUATIONS FOR SMALL RANGE (Cont'd)

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Filtration Media-Dual	-	-	-	-	-	-	-	-	-	-	-	-
Filtration Media Mixed	-	-	-	-	-	-	-	-	-	-	-	-
Backwash Pumping Facilities	1537-4000 ft^2	74.04	.607	.3205	.307	.283	-	-	-	-	-	-
Hydraulic Surface Wash	140-2000 ft^2	49.25	.475	.243	.128	.544	-	-	-	-	-	-
Air Water Backwash Fac.	140-200 ft^2	209.11	.368	.192	.303	.424	-	-	-	-	-	-
Wash Water Surge Basin	-	-	-	-	-	-	-	-	-	-	-	-
Filter Mod. Rapid Sand to High Rate	-	-	-	-	-	-	-	-	-	-	-	-
Continuous Auto Backwash Filter	360-5000 ft^2	1746.67	.473	.497	.0665	.365	-	-	-	-	-	-

TABLE 6. OPERATING AND MAINTENANCE COST EQUATIONS FOR SMALL RANGE (Cont'd)

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Recarbonation Basin	-	-	-	-	-	-	-	-	-	-	-	-
Recarbonation Liquid-CO2	380-1500 lb/day	620.85	.295	.1522	.625	.129	-	-	-	-	-	-
Recarbonation CO2 From Submerged Burn.	500-10,000 lb/day	2270.7	.835	.1013	-	-	.607	-	1.002	-	-	-
Recarbonation CO2 From Stack Gas	2500-50,000 lb/day	40.71	.785	.564	.209	.124	-	-	-	-	-	-
Multiple Hearth Recalcination	174-500 ft^2	63685.42	.534	.072	.054	.259	.426	-	1.007	-	-	-
Contact Basin Direct Filtration	-	-	-	-	-	-	-	-	-	-	-	-
Pressure Diatomite Filter	1-10 mgd	35345.6	.605	.373	.0344	.520	-	-	-	-	-	-
Vacuum Filtration Diatomite	1-50 mgd	53269.67	.517	.361	-	.500	-	-	-	-	-	-

TABLE 6. OPERATING AND MAINTENANCE COST EQUATIONS FOR SMALL RANGE (Cont'd)

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Pressure Filtration Plants	100-4000 ft^2	986.74	.611	.366	.1316	.419	-	-	-	-	-	-
In-Plant Pumping	1-10 mgd	22754.12	.696	.687	.037	.210	-	-	-	1.01382	-	-
Wash Water Storage	-	-	-	-	-	-	-	-	-	-	-	-
Reverse Osmosis	1-200 mgd	602393.12	.955	.4365	.4579	-	-	-	-	-	-	-
Pressure Ion Exchange Softening	1-4 mgd	9021.1	.493	.089	.293	.522	-	-	-	-	-	-
Gravity Ion Exchange	2-8 mgd	7892.78	.594	.068	.382	.435	-	-	-	-	-	-
Pressure Ion Exchange Nitrate Removal	1.1-12.3 mgd	33700.	.817	.047	.725	-	-	-	-	-	-	-
Activated Alumina Flouride	.7-2 mgd	4637.56	.191	.046	.123	.805	-	-	-	-	-	-

TABLE 6. OPERATING AND MAINTENACE COST EQUATIONS FOR SMALL RANGE (Cont'd)

$$OM=K_1\ USRT^b\ PR^c\ PPI^d\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Gravity GAC Contactors-Concrete	140-28000 ft^2	101.89	.761	.282	.150	.480	-	-	-	-	-	-
Gravity GAC Contactors Steel	31400-628000 ft^3	6.20	.903	.403	.112	.3936	-	-	-	-	-	-
Pressure Carbon Contactors	157-6790 ft^2	204.84	.781	.324	.203	.332	-	-	-	-	-	-
Convert Filter to GAC Contactor	-	-	-	-	-	-	-	-	-	-	-	-
Granular Act. Carbon	-	-	-	-	-	-	-	-	-	-	-	-
Make-Up Carbon Cost	10000-1000000 lb/yr	.513	.962	-	1.002	-	-	-	-	-	-	-
Capping Sand Filter w/anthracite	-	-	-	-	-	-	-	-	-	-	-	-
*Regional GAC Regeneration Trans. & Stor.	30000-3000000 lb/yr	.00018	1.006	-	.1996	.632	-	.153	-	-	.480	-

*Use MI^j instead of j^{MI} for estimating O&M cost for Regional GAC Regeneration Trans. & Stor.

TABLE 6. OPERATING AND MAINTENANCE COST EQUATIONS FOR SMALL RANGE (Cont'd)

$$OM=K_1\ USRT^b\ PR^c\ PPI^d\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
*Regional Multi-Hearth GAC Regen.	27-1510 ft^2	220.2	.796	-	-	.293	.503	-	1.002	-	-	-
Multi-Hearth GAC Regeneration	27-1510 ft^2	41630.3	.809	.045	-	.280	.581	-	1.002	-	-	-
Infrared Carbon Regeneration	2400-4000 lb/day	800.23	.648	.494	.144	.280	-	-	-	-	-	-
Fluidized Bed GAC Regeneration	6000-24,999 lb/day	964.58	.622	.0644	.188	.253	-	-	1.003	-	-	-
Powdered Carbon Regen-Fluidized	500-2000 lb/day	4233.7	.583	.370	.073	.252	.302	-	-	-	-	-
Powdered Carbon Regen.-Atomized	1000-10,000 lb/day	5453.1	.813	.0806	.033	.1416	.185	-	-	-	-	-
Chemical Sludge Pumping-Unthick.	20-200 gpm	1012.4	.231	.1044	.606	.222	-	-	-	-	-	-
Chemical Sludge Pumping Thickened	50-1250 gpm	1496.06	.553	.446	.353	.1087	-	-	-	-	-	-

*Multiply Equation by the percent of cost allocated to one participant in the regional system.

TABLE 6. OPERATING AND MAINTENANCE COST EQUATIONS FOR SMALL RANGE (Cont'd)

$OM=K_1\ USRT^b\ PR^c\ PPI^d\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Gravity Sludge Thickened-Lime	314-1200 ft^2	72.10	.236	.086	.140	.734	-	-	1.0055	-	-	-
Gravity Sludge Thickener-FECL3	314-1200 ft^2	72.39	.235	.086	.140	.738	-	-	1.004	-	-	-
Vacuum Filter	9.4-200 ft^2	3780.42	.564	.279	.306	.331	-	-	-	-	-	-
Belt Filter Press	15-60 gpm	8717.06	.419	.409	.082	.438	-	-	-	-	-	-
Filter Press	4.3-100 ft^3	14469.4	.127	.144	.0288	.787	-	-	-	-	-	-
Decanter Centrifuges	10-500 gpm	4044.1	.483	.3246	.222	.400	-	-	.900	-	-	-
Basket Centrifuges	3600-36,000 gpd	6544.42	.134	.440	.153	.322	-	-	-	-	-	-
Sand Drying Beds	5000-35,000 ft^2	7.69	.559	-	.0536	.839	-	.0955	-	-	-	-

TABLE 6. OPERATING AND MAINTENANCE COST EQUATIONS FOR SMALL RANGE (Cont'd)

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Sludge Dewater. Lagoons	10,000-50,000,000	.032	.926	-	-	.854	-	.130	-	-	-	-
*Sludge Disposal Sanitary-Sewer	20-10,000 gpm	.220	1.00006	-	-	-	-	-	-	-	-	-
Liquid Sludge Hauling	1.3-100 mg/yr	814.01	1.014	-	.2566	.453	-	.249	-	-	1.04696	-
Dewatered Sludge Hauling	1000-10,000 cy/yr	2.68	.690	-	.2427	.469	-	.25028	-	-	1.046454	-
Raw Water Pumping Fac.	1-10 mgd	23468.75	.703	.695	.037	.206	-	-	-	1.012651	-	-
Finished Water Pumping Fac.	1-10 mgd	30765.2	.733	.745	.0346	.169	-	-	-	1.00426	-	-
Clearwell Below-Ground	-	-	-	-	-	-	-	-	-	-	-	-
Clearwell Ground-Level	-	-	-	-	-	-	-	-	-	-	-	-

*Multiply Equation by the concentration of solids in the sludge in parts per million.

TABLE 6. OPERATING AND MAINTENANCE COST EQUATIONS FOR SMALL RANGE (Cont'd)

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Diffused Aeration Basin	1900-10,000 ft^3	472.32	.684	.553	.0726	.298	-	-	-	-	-	-
Aeration Aeration-Towers	680-6400 ft^3	31.36	.625	.373	.286	.225	-	-	-	-	-	-
Administration Building & Lab.	1-10 mgd	4813.27	.446	.1337	.103	.706	-	-	-	-	-	-

TABLE 7. OPERATING AND MAINTENANCE COST EQUATIONS FOR LARGE RANGE

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Chlorine Feed Cylinder	300-10,000 lb/day	194.17	.6206	.270	.1226	.521	-	-	-	-	-	-
Chlorine Feed On-Site Storage	2000-10,000 lb/day	430.25	.272	-	.370	.521	-	-	-	-	-	-
Chlorine Feed Rail Car	2000-10,000 lb/day	611.58	.221	.029	.4655	.468	-	-	-	-	-	-
Chlorine Dioxide Generation, Feed	100-3500 lb/day	347.1	.444	.076	.1798	.683	-	-	-	-	-	-
Ozone Generation, Systems	100-3500 lb/day	5664.87	.804	.776	.09	.074	-	-	-	-	-	-
Ozone contact Chamber	-	-	-	-	-	-	-	-	-	-	-	-
On-Site Hypochlorite Generation	100-10,000 lb/day	942.87	.876	.674	.166	.085	-	-	-	-	-	-
Alum Feed Liquid Stock	100-5400 lb/hry	1254.53	.361	.585	-	.254	-	-	-	-	-	-

TABLE 7. OPERATING AND MAINTENANCE COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Alum Feed Dry Stock	500-5000 lb/hr	13.11	.849	.1847	.0259	.743	-	-	-	-	-	-
Polymer Feed System	1-200 lb/day	2014.98	.0533	.294	.1037	.537	-	-	-	-	-	-
Lime Feed-With Recal.	1000-10,000 lb/hr	143.49	.466	.052	.038	.8946	-	-	-	-	-	-
Lime Feed-No Recal.	100-10,000 lb/hr	867.4	.2255	.087	.084	.818	-	-	-	-	-	-
Potassium Permanganate Feed	10-500 lb/hr	300.93	.178	.0789	.038	.883	-	-	-	-	-	-
Sulfuric Acid Feed	500-5000 gpd	4.48	.591	-	-	.926	-	-	-	-	-	-
Sodium Hydroxide Feed Systems	1000-10,000 lb/day	98.09	.511	.462	.091	.362	-	-	-	-	-	-
Ferrous Sulfate Feed Systems	400-5350 lb/hr	9.51	.7723	-	-	.823	-	-	-	-	-	-

TABLE 7. OPERATING AND MAINTENANCE COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Ferric Sulfate Feed	400-6600 lb/hr	9.82	.762	-	-	.815	-	-	-	-	-	-
Anhydrous Ammonia Feed	250-5000 lb/day	401.86	.3235	.07005	.414	.461	-	-	-	-	-	-
Aqua Ammonia Feed Facility	1000-5000 lb/day	99.80	.148	-	.2635	.715	-	-	-	-	-	-
Powdered Activated Carbon	350-7000 lb/hr	2832.24	.552	.381	.273	.276	-	-	-	-	-	-
Rapid Mix	1000-20,000 ft^3	61.81	.794	.717	-	.181	-	-	-	-	-	1.00251
Flocculation Vertical	1800-25,000 ft^3	21.82	.411	.148	.313	.439	-	-	-	-	-	1.0084
Flocculation Horizontal	30,000-1,000,000 ft^3	1.553	.785	.357	.399	-	-	-	-	-	-	1.018
Circular Clarifier Lime	1590-31,400 ft^2	12.60	.518	.059	.399	.506	-	-	1.007	-	-	-

TABLE 7. OPERATING AND MAINTENANCE COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Circular Clarifier-Fe and Alum	1500-31,400 ft^2	9.25	.522	-	.4116	.526	-	-	1.006	-	-	-
Rectangular Clarifier-Lime	600-4800 ft^2	16.84	.479	-	.178	.746	-	-	1.006	-	-	-
Rectangular Clarifier-Fe and Alum	600-4800 ft^2	17.56	.469	-	.181	.756	-	-	1.006	-	-	-
Upflow Solids Contact Clarifier	2500-14,500 ft^2	172.64	.411	.289	.1456	.440	-	-	1.0007	-	-	1.005
Tube Settling Modules	-	-	-	-	-	-	-	-	-	-	-	-
Gravity Filtration	1000-28,000 ft^2	249.75	.546	.147	.183	.610	-	-	-	-	-	-
Filtration Media Rapid Sand	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 7. OPERATING AND MAINTENANCE COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$OM = K_1 \ USRT^b \ PR^c \ PPI^d \ DHR^e \ NTG^f \ DSL^g \ UN^h \ i^{TDH} \ j^{MI} \ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Filtration Media Dual	-	-	-	-	-	-	-	-	-	-	-	-
Filtration Media-Mixed	-	-	-	-	-	-	-	-	-	-	-	-
Backwash Pumping Fac.	4000-28,000 ft^2	159.64	.650	.543	.219	.137	-	-	-	-	-	-
Hydraulic Surface Wash	2000-28,000 ft^2	37.51	.7146	.526	-	.315	-	-	-	-	-	-
Air Water Backwash Fac.	200-28,000 ft^2	154.89	.668	.572	.206	.129	-	-	-	-	-	-
Wash Water Surge Basin	-	-	-	-	-	-	-	-	-	-	-	-
Filter Mod. Rapid Sand	-	-	-	-	-	-	-	-	-	-	-	-
Continuous Auto Backwash	5000-70,400 ft^2	24.89	1.123	.728	.046	.174	-	-	-	-	-	-

TABLE 7. OPERATING AND MAINTENANCE COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Recarbonation Basin	-	-	-	-	-	-	-	-	-	-	-	-
Recarbonation Liquid CO2	1500-15,000 lb/day	253.72	.518	.312	.492	.086	-	-	-	-	-	-
Recarbonation CO2 from Sub. Bun.	500-10,000 lb/day	2270.7	.835	.1013	-	-	.607	-	1.002	-	-	-
Recarbonation CO2 From Stack	2500-50,000 lb/day	40.71	.785	.564	.209	.124	-	-	-	-	-	-
Multiple Hearth Recalc.	500-2930 ft^2	15017.	.903	-	-	.251	.590	-	1.0026	-	-	-
Contact Basin Direct Filtra.	-	-	-	-	-	-	-	-	-	-	-	-
Pressure Diatomite Filter	10-200 mgd	132910.72	.628	.545	-	.298	-	-	-	-	-	-
Vacuum Filtration Diatomite	50-200 mgd	278483.84	.4144	.5235	-	.336	-	-	-	-	-	-

TABLE 7. OPERATING AND MAINTENANCE COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Pressure Filtration Plant	4000-28,000 ft^2	1898.54	.620	.435	.141	.294	-	-	-	-	-	-
In-Plant Pumping	10-200 mgd	49859.7	.812	.821	-	-	-	-	-	1.017	-	-
Wash Water Storage	-	-	-	-	-	-	-	-	-	-	-	-
Reverse Osmosis	1-200 mgd	602393.12	.955	.4365	.4579	-	-	-	-	-	-	-
Pressure Ion Exchange Softening	4-123 mgd	12615.4	.800	.046	.619	-	-	-	-	-	-	-
Gravity Ion Exchange	8-150 mgd	7163.91	.809	.079	.682	.188	-	-	-	-	-	-
Pressure Ion Exchange Nit.	1.1-12.3 mgd	33700.	.817	.047	.725	-	-	-	-	-	-	-
Activated Alumina Flouride	2-135 mgd	11257.97	.682	.1596	.526	.263	-	-	-	-	-	-

TABLE 7. OPERATING AND MAINTENANCE COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Gravity GAC Contactors-Conc.	350-280,000 ft^2	101.89	.761	.282	.150	.480	-	-	-	-	-	-
Gravity GAC Contact-Steel	31,400-628,000 ft^3	6.20	.903	.403	.112	.3936	-	-	-	-	-	-
Pressure Carbon Cont.	157-6790 ft^2	204.84	.7809	.324	.2029	.332	-	-	-	-	-	-
Convert Filter GAC Cont.	-	-	-	-	-	-	-	-	-	-	-	-
Granular Activated Carbon	-	-	-	-	-	-	-	-	-	-	-	-
Capping Sand Filter w/anth.	-	-	-	-	-	-	-	-	-	-	-	-
*Regional GAC Regen. Trans. & Storage	30,000-3,000,000 lb/yr	.00018	1.006	-	.1996	.632	-	.153	-	-	.480	-

* Instead of using j^{MI}, use MI^j when estimating O&M cost for Regional GAC Regen. Trans. & Storage

TABLE 7. OPERATING AND MAINTENANCE COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Gravity Sludge Thickener-Lime	1200-17,800 ft^2	17.06	.538	.149	.299	.493	-	-	1.006	-	-	-
Gravity Sludge Thickener-FECL3	1200-17,800 ft^2	16.88	.508	.106	.321	.524	-	-	1.007	-	-	-
Vacuum Filter	200-1320 ft^2	7239.52	.552	.351	.279	.292	-	-	-	-	-	-
Belt Filter Press	60-450 gpm	961.26	.931	.335	.137	.396	-	-	-	-	-	-
Filter Press	100-896 ft^3	806.83	.625	-	-	.801	-	-	-	-	-	-
Decanter Centrifuges	10-500 gpm	4044.1	.483	.3246	.222	.400	-	-	.900	-	-	-
Basket Centrifuges	36,000-720,000 gpd	3.15	.968	.649	.0944	.175	-	-	-	-	-	-
Sand Drying Beds	35,000-400,000 ft^2	.141	.955	-	-	.789	-	.138	-	-	-	-

TABLE 7. OPERATING AND MAINTENANCE COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Sludge Dewatering Lagoons	10,000-5,000,000 cf/yr	.032	.926	-	-	.854	-	.130	-	-	-	-
*Sludge Disposal Sanitary Sewer	20-10,000 gpm	.220	1.00006	-	-	-	-	-	-	-	-	-
Liquid Sludge Hauling	1.3-100 mg/yr	814.01	1.014	-	.2566	.453	-	.249	-	-	1.04696	-
Dewatered Sludge Hauling	10,000-300,000 cy/yr	.117	1.02274	-	.266	.4705	-	.230	-	-	1.04621	-
Raw Water Pumping Gac.	10-200 mgd	27815.7	.946	.868	-	.068	-	-	-	1.015383	-	-
Finished Water Pumping	10-300 mgd	31646.8	.955	.887	-	.0583	-	-	-	1.004986	-	-
Clearwell Below Ground	-	-	-	-	-	-	-	-	-	-	-	-
Clearwell Ground Level	-	-	-	-	-	-	-	-	-	-	-	-

*Multipy equation by the concentration of solids in the sludge in parts per million.

TABLE 7. OPERATING AND MAINTENANCE COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Regional Multi Hearth GAC Regen*	27-1510 ft^2	220.2	.796	-	-	.293	.503	-	1.01	.998	-	-
Multi Hearth GAC Regen	27-1510 ft^2	41630.3	.809	.045	-	.280	.589	-	1.002	-	-	-
Infrared Carbon Regen. Furnace	4000-60,000 lb/day	410.31	.865	.720	.069	.136	-	-	-	-	-	-
Fluidized Bed GAC Regen.	6000-24,000 lb/day	964.58	.622	.0644	.188	.253	.302	-	1.000	-	-	-
Powdered Carbon Regen. Fluidized	2000-33,400 lb/day	5879.6	.767	.476	-	-	.313	-	-	-	-	-
Powdered Carbon Regen. Atomized	1000-10,000 lb/day	5453.1	.813	.0806	.033	.1416	.683	-	-	-	-	-
Chemical Sludge Pumping-Unthick.	200-10,000 gpm	244.94	.6366	.263	.532	.128	-	-	-	-	-	-
Chemical Sludge Pumping-Thick.	50-1250 gpm	1496.06	.553	.446	.353	.1087	-	-	-	-	-	-

*Multiply equation by the percent of cost allocated to one participant in the regional system.

TABLE 7. OPERATING AND MAINTENANCE COST EQUATIONS FOR LARGE RANGE (Cont'd)

$$OM = K_1\ USRT^b\ PR^c\ PPI^d\ DHR^e\ NTG^f\ DSL^g\ UN^h\ i^{TDH}\ j^{MI}\ k^G$$

PROCESS NAME	USRT RANGE	K_1	b	c	d	e	f	g	h	i	j	k
Diffused Aeration Basin	10,000-380,000 ft^3	112.08	.9247	.720	-	.205	-	-	-	-	-	-
Aeration-Aeration Towers	6400-256,000 ft^3	6.54	.946	.654	.176	.092	-	-	-	-	-	-
Admin. Building & Lab.	10-200 mgd	9884.6	.367	.1836	.114	.672	-	-	-	-	-	-

The following equations illustrate the estimation procedure over the different size ranges, for Cl_2 feed cylinder storage:

$$OM_{CL} = 1506.1\ USRT_1^{0.105} PR^{0.078} PPI^{0.273} DHR^{0.589} \quad (10 < USRT \leq 300) \qquad (4)$$

$$OM_{CL} = 194.17\ USRT_2^{0.62} PR^{0.27} PPI^{0.122} DHR^{0.521} \quad (300 < USRT_2 < 10,000) \qquad (5)$$

where:

OM_{CL} = annual operating and maintenance cost in \$/yr for Cl_2 feed cylinder storage

$USRT_1$ = design parameter in lb/day over the range 10-300

$USRT_2$ = design parameter in lb/day over the range >300-10,000

Between equations 4 and 5 the parameters shift in value. The exponent drops significantly for USRT at lower size ranges; this shows that the cost becomes less influenced by USRT. For those processes where the number of units is important a value has been entered under the column headed by n in the capital cost equations (Table 4 and 5) and in the column headed by h in the operating and maintenance equation (Table 6 and 7) of the table. Where use of "Units" is not appropriate a, "-" appears in these columns. An example of the application of these equations, is given in a later section. A computer program (Appendix A) has been developed to utilize the equations in Tables 4, 5, 6, and 7.

As mentioned earlier the capital cost equations were developed to provide annualized capital costs inculding interest based on an assumption of 8% interest and a 20-year amortization period. Conversion to a different interest rate and amortization period is a fairly simple process. Equation (6) is the equation for the annual equivalent cost to provide repayment and return on capital:

$$AE = (B-V) \left[\frac{i(1+i)^n}{(1+i)^n-1} \right] + Vi \qquad (6)$$

where:

AE = annual cost in \$/yr

B = first cost

V = estimated salvage value

i = interest rate

n = amortization period

substituting $i = 0.08$, $n = 20$ and $V=0$, yields

$$AE = B\,[0.102]$$

If AE is to be calculated for an interest rate of $i = 10$ and $n = 20$ and $V=0$ equation (6) becomes:

$$AE = [0.117]$$

The values from the equations in Table 4 would be increased by the ratio of the calculated values in the brackets above or

$$R = \frac{0.117}{0.102}$$

$$= 1.152$$

Therefore for a base of 10% and 20 yrs all of the annual capital costs for the equations in Tables 4 and 5 would be multipled by 1.152.

ESTIMATES OF CONSTRUCTION AND O&M COST COMPONENTS

Often in updating or checking cost estimates, it is useful to know the quantities of the individual components that makeup these estimates. In the following sections, a methodology is presented for providing these kinds of estimates.

CONSTRUCTION COST COMPONENTS

Table 8 presents construction cost distribution factors based on the following components: excavation; manufactured equipment; concrete; steel; labor; pipe and valves; electrical and instrumentation; and housing. For example, the construction cost for Chlorine Feed-Cylinder Storage is as follows: 0% excavation, 50% manufactured equipment, 0% concrete, 0% steel and 6% labor, 4% pipes and valves, 6% electrical and instrumentation, and 34% housing. These factors are useful for updating costs when various factors escalate at different rates. They can also be used to compare cost estimates from different sources.

OPERATING AND MAINTENANCE COMPONENTS

Operating and maintenance components used in development of these cost curves are: process electricity in kilowatt hours per year; maintenance material in dollars per year; labor in hours per year; building energy in kilowatt hours per year; natural gas in standard cubic feet per year; and diesel fuel in gallons per year. Equations

TABLE 8. CONSTRUCTION COST FACTORS (Fraction of Total)

Unit Process	Excavation	Manufactured Equipment	Concrete	Steel	Labor	Pipe & Valves	Electrical & Instr.	Housing
CL2 Feed-Cylinder	.00	.50	.00	.00	.06	.04	.06	.34
Cl2 Feed-On Site Storage	.00	.81	.00	.02	.08	.03	.05	.01
Cl2 Feed Rail Car	.00	.82	.00	.00	.06	.04	.06	.02
Chlorine Dioxide Feed	.00	.41	.00	.00	.32	.02	.03	.22
Ozone Generation	.00	.79	.00	.00	.17	.00	.00	.04
Ozone Contact Chamber	.00	.00	.19	.32	.43	.00	.00	.00
On-Site Hypochlorite	.00	.60	.00	.00	.21	.00	.06	.13
Alum Feed Liquid Stock	.00	.42	.00	.00	.08	.03	.12	.35
Alum Feed Dry Stock	.00	.40	.00	.00	.03	.07	.06	.44
Polymer Feed	.00	.69	.00	.00	.04	.01	.07	.19
Lime Feed-No Recalcination	.00	.53	.00	.00	.02	.07	.08	.30
Lime Feed w/Recalcination	.00	.67	.00	.00	.02	.05	.10	.16
Potassium Permanganate	.00	.33	.00	.00	.06	.10	.33	.18
Sulfuric Acid Feed	.00	.46	.00	.00	.11	.11	.22	.10
Sodium Hydroxide	.00	.39	.00	.00	.05	.05	.18	.33

TABLE 8. CONSTRUCTION COST FACTORS (Fraction of Total) (Contd)

Unit Process	Excavation	Manufactured Equipment	Concrete	Steel	Labor	Pipe & Valves	Electrical & Instr.	Housing
Ferrous Sulfate	.00	.38	.00	.00	.03	.06	.06	.47
Ferric Sulfate	.00	.38	.00	.00	.03	.06	.06	.47
Anhydrous Ammonia	.00	.55	.00	.00	.15	.10	.11	.09
Aqua Ammonia	.00	.71	.00	.00	.06	.05	.18	.00
Powdered Activated Carbon	.01	.44	.02	.04	.05	.15	.24	.05
Rapid Mix G=300	.03	.31	.07	.11	.18	.00	.30	.00
Rapid Mix G=600	.02	.40	.06	.09	.17	.00	.26	.00
Rapid Mix G=900	.01	.60	.04	.06	.12	.00	.17	.00
Flocculation Horiz.-G-20	.04	.24	.12	.17	.25	.00	.18	.00
Flocculation Horiz.-G=50	.04	.27	.10	.17	.26	.00	.16	.00
Flocculation Horiz.-G=80	.02	.34	.08	.13	.24	.00	.19	.00
Flocculation-Vert.-G=20	.02	.27	.07	.12	.27	.00	.26	.00
Flocculation-Vert.G=50	.03	.18	.09	.14	.25	.00	.32	.00
Flocculation-Vert.G=80	.03	.23	.09	.15	.29	.00	.22	.00

TABLE 8. CONSTRUCTION COST FACTORS (Fraction of Total) (Contd)

Unit Process	Excavation	Manufactured Equipment	Concrete	Steel	Labor	Pipe & Valves	Electrical & Instr.	Housing
Circular Clarif.-Lime	.02	.31	.08	.37	.14	.05	.03	.00
Circular Clarif. FECL3 & Alum	.02	.31	.08	.37	.14	.05	.03	.00
Rect. Clarif. Lime	.04	.27	.10	.25	.21	.11	.02	.00
Rect. Clarf. FECL3 & Alum	.04	.27	.10	.25	.21	.11	.02	.00
Upflow Solids Cont. G=70	.04	.53	.07	.10	.25	.00	.01	.00
Upflow Solids Contact G=110	.04	.53	.07	.10	.25	.00	.01	.00
Upflow Solids Contact G=150	.04	.53	.07	.10	.25	.00	.01	.00
Tube Settling Modules	.00	.50	.00	.33	.17	.00	.00	.00
Gravity Filtrtation	.01	.16	.07	.05	.24	.24	.07	.16
Back Wash Pumping	.00	.49	.00	.00	.06	.23	.22	.00
Hydraulic Surface Ash	.00	.52	.00	.00	.08	.10	.30	.00
Air-Water Backwash	.00	.41	.00	.00	.09	.39	.11	.00
Wash Water Surge Basins	.01	.00	.30	.18	.44	.05	.00	.02
Filter Mod-Rap Sand to Hi-Rate	.00	.00	.00	.00	.38	.45	.17	.00
Cont. Auto Backwash	.01	.50	.07	.07	.15	.03	.02	.19

TABLE 8. CONSTRUCTION COST FACTORS (Fraction of Total) (Contd)

Unit Process	Excavation	Manufactured Equipment	Concrete	Steel	Labor	Pipe & Valves	Electrical & Instr.	Housing
Recarbonation Basin	.07	.00	.20	.32	.39	.02	.00	.00
Recarbonation Liquid CO2 Feed	.00	.59	.00	.00	.21	.09	.00	.11
Recarbonation CO2 submerged BN	.00	.56	.00	.00	.20	.17	.07	.00
Recarbonation CO2 Stack Gas	.00	.42	.00	.00	.27	.15	.16	.00
Multiple Hearth Recalcination	.00	.63	.00	.00	.27	.01	.01	.08
Contact Basin-Direct Filtration	.07	.00	.20	.34	.39	.00	.00	.00
Pressure Diatomite Filtration	.01	.62	.01	.01	.15	.04	.07	.09
Vacuum diatomite Filtration	.01	.32	.01	.01	.22	.22	.05	.16
Pressure Filtration	.01	.45	.01	.01	.07	.25	.12	.08
In-Plant Pumping	.01	.22	.02	.03	.28	.27	.11	.06
Wash Water Storage	.02	.00	.01	.43	.54	.00	.00	.00
Reverse osmosis	.00	.61	.00	.00	.12	.00	.15	.12
Pressure Ion-Exchange Softening	.01	.52	.01	.01	.01	.16	.16	.12
Gravity Ion Exchange Softening	.01	.59	.04	.03	.09	.10	.06	.08

TABLE 8. CONSTRUCTION COST FACTORS (Fraction of Total) (Contd)

Unit Process	Excavation	Manufactured Equipment	Concrete	Steel	Labor	Pipe & Valves	Electrical & Instr.	Housing
Pressure Ion Exchange NO3	.01	.68	.01	.01	.11	.06	.06	.06
Activated Alumina Fluor. Rem.	.00	.52	.00	.00	.12	.16	.05	.15
Gravity GAC Cont. Concrete	.01	.14	.05	.03	.20	.41	.02	.14
Gravity GAC Cont. Steel	.01	.43	.01	.01	.08	.19	.06	.21
Pressure Carbon Contactors	.01	.47	.01	.01	.06	.17	.10	.17
Convt. Filt. to GAC Cont.	.00	.12	.00	.00	.25	.62	.02	.00
Capping Sand Filter w/Ant.	.00	.00	.68	.00	.32	.00	.00	.00
Regional GAC Regeneration-T&S	.01	.16	.02	.39	.37	.05	.00	.00
Regional Multiple hearth	.00	.53	.00	.00	.28	.02	.01	.16
Mult. Hearth GAC Regeneration	.00	.53	.00	.00	.28	.02	.01	.16
Infrared Carbonation Furn.	.00	.64	.00	.00	.18	.01	.08	.09
Fluidized Bed Regeneration	.00	.68	.00	.00	.22	.00	.01	.09

TABLE 8. CONSTRUCTION COST FACTORS (Fraction of Total) (Contd)

Unit Process	Excavation	Manufactured Equipment	Concrete	Steel	Labor	Pipe & Valves	Electrical & Instr.	Housing
Powdered Carbon Fluid.	.00	.49	.00	.00	.35	.00	.15	.01
Powdered Carbon - Atom.	.00	.76	.00	.00	.00	.00	.12	.12
Chem. Slude Unthickened	.01	.15	.06	.06	.24	.23	.14	.11
Chem. Sludge Thickened	.00	.64	.00	.00	.13	.04	.07	.12
Gravity Sludge Lime	.03	.41	.12	.16	.27	.00	.01	.00
Gravity Slug Alum-FECL3	.03	.41	.12	.16	.27	.00	.01	.00
Vacuum Filters	.00	.46	.00	.00	.16	.02	.02	.34
Belt Filter Press	.00	.69	.00	.00	.21	.02	.01	.07
Filter Press	.00	.61	.00	.00	.18	.01	.01	.19
Decanter Centrifuges	.00	.48	.00	.00	.17	.04	.03	.28
Basket Centrifuges	.00	.53	.00	.00	.17	.05	.01	.24
Sand Drying Beds	.06	.00	.08	.02	.64	.20	.00	.00
Sludge Dewat. Lagoons	.51	.00	.04	.01	.28	.16	.00	.00

TABLE 8. CONSTRUCTION COST FACTORS (Fraction of Total) (Contd)

Unit Process	Excavation	Manufactured Equipment	Concrete	Steel	Labor	Pipe & Valves	Electrical & Instr.	Housing
Raw Water Pumping	.00	.42	.00	.00	.17	.32	.09	.00
Finished Water Pumping	.00	.41	.00	.00	.11	.22	.26	.00
Clear Well BLW-Ground	.01	.00	.35	.17	.44	.00	.03	.00
Clearwell Ground Level	.00	.71	.08	.06	.01	.09	.05	.00
Diffused Aer. Basin	.01	.61	.02	.03	.16	.00	.15	.02
Aeration Aera. Twrs.	.01	.67	.06	.08	.14	.00	.04	.00
Admin. Lab. & Maint.	.00	.00	.00	.00	.00	.00	.00	1.00

have been developed so that the amount of each component is estimated based on the magnitude of the process variable (Table 9). An equation of the following form can be used to estimate these components:

$$CQ = A\ USRT^{r} \qquad (7)$$

where:

CQ = component quantity

$USRT$ = level of process parameter

A, r = constants estimated from regression equation

To illustrate the use of this approach consider the case of Chlorine Feed Cylinder Storage system operating at 450 lb/hr but with a maximum capacity of 670 lb/hr. To estimate the amount of process energy, the value of 450 lb/hr is used in equation (7) as follows:

$$CQ_1 = 1.25\ (450)^{1.11} \qquad (8)$$

$$CQ_1 = 1105\ \text{kwhr/yr}$$

where:

CQ_1 = the number of process kilowatt hours per year for cylinder storage at a throughput level of 450 lb/hr.

Building energy is based on the maximum size of the facility and is therefore estimated as follows:

$$CQ_2 = 490.95\ (670)^{0.801} \qquad (9)$$

$$CQ_2 = 79104.6\ \text{kwhr/yr}$$

where:

CQ_2 = the number of building energy hours per year for cylinder storage at a design level of 670 lb/hr.

The total electric usage is therefore 80,210 kwhr/yr.

Some modifications of the O&M components are based on such considerations as Total Dynamic Head for pumping or rates of transport for sludge hauling. Table 10 contains some of these special forms of component equations.

TABLE 9. OPERATING AND MAINTENANCE COST COMPONENTS

UNIT PROCESS	PROCESS ELECTRICITY (kwhr/yr)		MAINTENANCE MATERIAL ($/yr)		LABOR (hrs/yr)		BUILDING ENERGY (kwhr/yr)		Diesel (gal/yr)		Natural Gas (scf/yr)	
	A	a	A	a	A	a	A	a	A	a	A	a
CL2 Feed Cylinder Stor.	1.25	1.1105	441.89	.305	15.96	.626	490.95	.781	-	-	-	-
CL2 Feed-On Storage	.445	1.073	224.87	.386	485.23	.1008	303.04	.396	-	-	-	-
CL2 Feed From Rail Car	.445	1.073	224.87	.386	626.25	.0266	303.04	.396	-	-	-	-
Chlorine Dioxide Generation	103.74	.662	350.13	.387	45.14	.562	2431.5	.462	-	-	-	-
Ozone Generation	4940.5	.918	210.4	.603	43.8	.518	88.5	.872	-	-	-	-
On-Site Hypochlorite	941.8	.995	39.24	.8098	43.43	.483	5647.68	.372	-	-	-	-
Alum-Liquid Feed	1655.4	.179	45.67	.127	54.10	.03166	997.8	.579	-	-	-	-
Alum-Dry Feed	2130.9	.162	6.778	.586	6.67	.754	442.12	.733	-	-	-	-
Polymer Feed	17298.56	.00003	187.43	.1266	174.31	.0476	6822.3	.068	-	-	-	-
Lime Feed Without Recalcination	2118.4	.1487	495.8	.1389	311.76	.26016	4072.6	.381	-	-	-	-

TABLE 9. OPERATING AND MAINTENANCE COST COMPONENTS (Cont'd)

UNIT PROCESS	PROCESS ELECTRICITY (kwhr/yr)		MAINTENANCE MATERIAL ($/yr)		LABOR (hrs/yr)		BUILDING ENERGY (kwhr/yr)		Diesel (gal/yr)		Natural Gas (scf/yr)	
	A	a	A	a	A	a	A	a	A	a	A	a
Lime Feed With Recalcination	24.28	.753	314.46	.191	87.5	.4678	756.7	.481	-	-	-	-
Potassium Permanganate	1197.32	.244	37.85	.221	163.58	.179	685.44	.297	-	-	-	-
Sulfuric Acid Feed	281.22	.2738	28.77	.182	5.78	.5278	3668.77	.07343	-	-	-	-
Sodium Hydroxide	597.43	.282	9.89	.413	30.96	.2038	86.94	.729	-	-	-	-
Ferrous Sulfate	1759.9	.1874	6.51	.5695	6.69	.742	388.83	.745	-	-	-	-
Ferric Sulfate	1569.96	.203	3.703	.642	4.439	.783	251.02	.789	-	-	-	-
Anhydrous Amm.	1.042	1.258	392.37	.344	124.21	.237	6023.1	.0856	-	-	-	-
Aqua amm.	570.	0.0	4.67	.571	152.	0.0	-	-	-	-	-	-
Powdered Activated Carbon	35744.56	.4696	240.99	.6296	46.03	.5875	-	-	-	-	-	-
Circular Clarifier Lime	282.44	.3755	1.968	.7336	9.66	.376	-	-	-	-	-	-
Circular Clarifier FECL3	172.24	.392	1.968	.7336	9.66	.376	-	-	-	-	-	-
Rectangular Clarifier-Lime	91.55	.555	6.436	.595	11.48	.4379	-	-	-	-	-	-

TABLE 9. OPERATING AND MAINTENANCE COST COMPONENTS (Cont'd)

UNIT PROCESS	PROCESS ELECTRICITY (kwhr/yr)		MAINTENANCE MATERIAL ($/yr)		LABOR (hrs/yr)		BUILDING ENERGY (kwhr/yr)		Diesel (gal/yr)		Natural Gas (scf/yr)	
	A	a	A	a	A	a	A	a	A	a	A	a
Rectangular Clarifier FECL3 & Alum	272.69	.385	6.43	.595	11.48	.4379	-	-	-	-	-	-
Backwash Pumping	23.65	1.001	196.14	.318	88.36	.1403	-	-	-	-	-	-
Hydraulic Surface Wash	14.14	.9978	57.37	.2233	7.57	.420	-	-	-	-	-	-
Air-Water Backwash	24.	1.001	121.6	.369	88.20	.140	-	-	-	-	-	-
Continuous Automatic Backwash	3.60	1.116	1.278	9.228	.2268	1.0166	73.37	1.1097	-	-	-	-
Recarbonation Liquid CO2	22.28	.973	284.48	.367	6.06	.3912	2377.	.212	-	-	-	-
Recarbonation CO2 submerged Burner	1210.18	.613	593.9	.158	80.	0.0	-	-	-	-	3158.	.999
Recarbonation CO2 Stack Gas	17.44	.999	601.99	.447	.739	.637	-	-	-	-	-	-
Mult. Hearth Recalcination Contact Basin	3895.65	.783	142.65	.693	95.25	.668	989.85	.429	-	-	86798.	1.013
Pressure Diatomite Filter	133115.9	.966	844.54	.853	3760.	.411	45858.5	.786	-	-	-	-
Vacuum Diatomite Filter	56991.5	1.002	766.1	.899	3760.	.411	68990.6	.753	-	-	-	-

TABLE 9. OPERATING AND MAINTENANCE COST COMPONENTS (Cont'd)

UNIT PROCESS	PROCESS ELECTRICITY (kwhr/yr)		MAINTENANCE MATERIAL ($/yr)		LABOR (hrs/yr)		BUILDING ENERGY (kwhr/yr)		Diesel (gal/yr)		Natural Gas (scf/yr)	
	A	a	A	a	A	a	A	a	A	a	A	a
Pressure Filtration	235.05	1.00	27.36	.775	44.20	.589	308.5	.8945	-	-	-	-
Reverse Osmosis	2212483.	1.000	92593	.964	894.17	.444	93450.1	.956	-	-	-	-
Pressure-Ion Exchange Softening	2059.1	.999	4436.4	.993	979.0	.515	38685.	.953	-	-	-	-
Gravity Ion Exchange Softening	982.58	.999	4241.	.976	672.1	.623	25932.2	.885	-	-	-	-
Pressure Ion Exchange-NO3	1726.5	.9987	22962.5	1.01	1930.7	.229	49002.7	.752	-	-	-	-
Activated Alumina	4.17	.508	1939.8	1.09	631.6	.643	26761.5	.921	-	-	-	-
Gravity GAC Cont-Concrete	4.85	1.0005	31.33	.683	9.87	.712	408.15	.882	-	-	-	-
Gravity-GAC Cont-Steel	.39	.9993	2.80	.736	.17	.8974	36.59	.949	-	-	-	-
Pressure Carbon Contactors	4.21	1.0354	6.80	.963	20.10	.6435	1344.25	.8166	-	-	-	-

TABLE 9. OPERATING AND MAINTENANCE COST COMPONENTS (Cont'd)

UNIT PROCESS	PROCESS ELECTRICITY (kwhr/yr)		MAINTENANCE MATERIAL ($/yr)		LABOR (hrs/yr)		BUILDING ENERGY (kwhr/yr)		Diesel (gal/yr)		Natural Gas (scf/yr)	
	A	a	A	a	A	a	A	a	A	a	A	a
Make-Up Carbon	-	-	1.037	.961	-	-	-	-	-	-	-	-
Regional Multiple Hearth	44123.5	.4495	992.6	.369	94.75	.7104	1985.2	.4346	-	-	254413.	.9097
Mult. Hearth GAC-Regeneration	44123.5	.4495	992.6	.369	94.75	.7104	1985.2	.4346	-	-	254413.	.9097
Infrared Carbon Regeneration	315.9	.9845	381.5	.409	9.73	.6374	45.20	.6898	-	-	-	-
Fluidized Bed GAC Regeneration	20.99	1.00003	2465.6	.206	181.9	.282	-	-	-	-	1117.7	.997
Powdered Carbon Regeneration-Fluidized	2791.64	.752	364.1	.2716	46.68	.414	-	-	-	-	6408.	.921
Powdered Carbon Regeneration Atomized	25.02	1.0623	325.22	.243	284.18	.1796	-	-	-	-	9057.	.9476
Chemical Sludge Unthickened	63.7	1.0005	145.6	.5957	26.36	.373	4083.5	.163	-	-	-	-

TABLE 9. OPERATING AND MAINTENANCE COST COMPONENTS (Cont'd)

UNIT PROCESS	PROCESS ELECTRICITY (kwhr/yr)		MAINTENANCE MATERIAL ($/yr)		LABOR (hrs/yr)		BUILDING ENERGY (kwhr/yr)		Diesel (gal/yr)		Natural Gas (scf/yr)	
	A	a	A	a	A	a	A	a	A	a	A	a
Chemical Sludge Thickened	887.61	.8652	547.94	.3866	23.44	.389	1932.19	.223	-	-	-	-
Gravity Sludge Thick-Lime	13.07	.814	.99	.8016	16.53	.3142	-	-	-	-	-	-
Gravity-Sludge Thick.-Alum-FEC	40.83	.648	.99	.8016	16.53	.314	-	-	-	-	-	-
Vacuum Filter	4061.7	.872	981.1	.6089	129.25	.6098	50660.5	.239	-	-	-	-
Belt Filter Press	4645.	1.008	73.13	.994	58.2	.857	19704.	.507	-	-	-	-
Filter Press	4447.8	.806	285.5	.536	674.74	.547	669.25	.315	-	-	-	-
Decanter Centrifuges	1043.3	1.039	770.3	.4648	363.2	.330	53240.2	.247				
Basket Centrifuges	.907	1.102	.24	.8556	.1856	.759	1.657	1.059	-	-	-	-
Sand Drying Bed	-	-	.033	.993	.116	.913	-	-	.06	1.000	-	-
Sludge Dewatering Lagoon	-	-	.031	.738	.024	.9146	-	-	.014	.970	-	-
Diffused Aerat.	141.43	1.005	48.33	.4917	1.61	.774	300.	.443	-	-	-	-
Aeration Towers	10.8	.995	.180	.9457	.188	.718	-	-	-	-	-	-
Admin., Lab & Maint.	-	-	1540.4	.482	1795.0	.399	73872.	.489	-	-	-	-

TABLE 10. OPERATING AND MAINTENANCE COST COMPONENTS

UNIT PROCESS	Process Energy			Maintenance Material			Labor			Diesel Fuel		
	A	r	X	A	r	X	A	r	X	A	r	x
		(kwhr/yr)			($/yr - 1978)			(hrs/yr)			(gal/yr)	
*Rapid Mix	18.1	1.000	1.00316	.205	.717	1.0	11.8	.484	1.0	-	-	-
*Flocculation Vert. Turbine	9.216	1.007	.9536	9.32	.4785	1.0	35.2	.1644	1.0	-	-	-
*Flocculation Horiz. Turbine	.0459	1.048	1.049	.272	.831	.9998	5.746	.354	1.0005	-	-	-
+Liquid Sludge Hauling	-	-	-	536.7	1.000	1.05979	195.05	1.001	1.03124	468.94	1.000	1.05979
+Detwatered Sludge Sludge Hauling	-	-	-	.0892	1.0088	1.05979	.0267	1.0268	1.03124	.096	.9915	1.05979
++Raw Water Pumping	31847.	.985	1.01735	189.3	.938	1.0	140.	.649	1.0	-	-	-
++Finished Water Pumping	37387.	.976	1.00552	200.6	.916	1.0	90.2	.755	1.0	-	-	-
++In-Plant Pumping	31665.	.9847	1.0192	191.2	.944	1.0	134.9	.655	1.0	-	-	-
**Regional Off Site Regeneration	-	-	-	.000018	1.0062	1.0	.000126	1.0139	.249	.0000184	1.003	1.00
*Upflow Solids Contact Clarifiers	6.79	.910	1.0157	42.98	.418	1.0	219.3	.1226	1.0	-	-	-

+C = A USRT X^{MI}

++C = A $USRT^{r}$ X^{TDH}

*C = A USRT X^{G}

**C = A USRT MI^{x}

For example to estimate the process energy in kilowatt hours per year for rapid mix with a volume of 1000 cubic feet the following equation would be used

$$RM_e = A\ USRT^r\ X^G \qquad (10)$$

where:

RM_e = Number of kilowatt hours per year of process energy for rapid mix

A = 18.1 (from table 10)

USRT = 1000 cubic feet

r = 1.000 (from Table 10)

X = 1.00316 (from table 10)

G = 300

Substituting the various values given into equation (10) yields

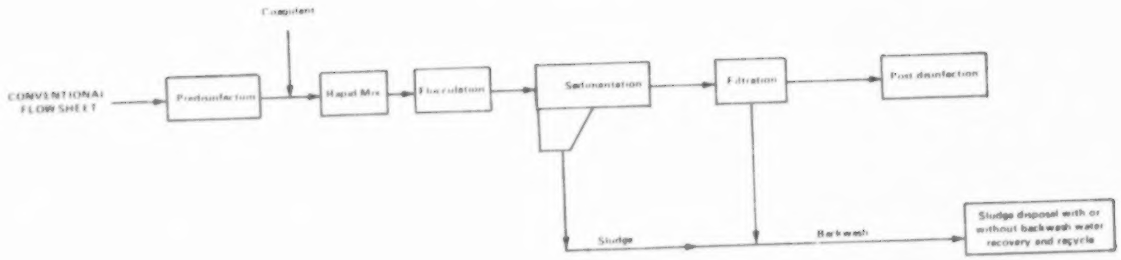
$$RM_e = 18.1\ (1000)^{1.000}\ (1.00316)^{300}$$

$$= 46{,}638.07 \text{ kwhr/yr}$$

Given the level of significance of these equations a value of RM_e = 46,600 kwhr/yr is a more appropriate value to use.

APPLICATION OF EQUATIONS

The equations in Tables 4, 5, 6 and 7 can be used to provide rough estimates for the cost of various combinations of unit processes. To illustrate this application the following example is provided. Figure 6 is a flow diagram for a conventional water treatment plant. Table 11 lists standard input factors for the equations. Table 12 lists a series of unit processes (consistent with Figure 6) and assumed design levels, assuming a 40 mgd conventional treatment plant operating at 28 mgd. Column 1 of Table 12 lists the individual unit processes that make up the treatment plant. Column 2 shows the design parameters, Column 3 contains annual construction cost, Column 4 contains the operating parameter, and column 5 contains the operating cost. The annual O&M and capital costs are added together and the resulting sum is divided by the average flow through the plant. If an assumption is made of an average flow at 28 mgd the resulting cost is ¢25.9/1000 gal (6.8¢/kl) total production cost.



Treatment Step No ① ② ③ ④ ⑤ ⑥ ⑦ ⑧

SUBSTANCE TO BE REMOVED	UPPER LIMITING RAW WATER CONCENTRATION	MAXIMUM CONTAMINANT LIMIT	COAGULANT TYPE	COAGULANT DOSAGE	MODIFICATION
COLIFORM BACTERIA	20,000 MPN/100 ML	1 PER 100 ML	USUALLY ALUM	5 TO 140 MG/L	NONE
TURBIDITY	1,000 TU	1 TU	USUALLY ALUM	5 TO 140 MG/L	NONE
VIRUS	1,000 PFU/GALLON	NONE ESTABLISHED (TURBIDITY 1 TU)	USUALLY ALUM	5 TO 140 MG/L	NONE
SILVER	0.17 MG/L	0.05 MG/L	ALUM	30 MG/L + pH 6 TO 8	NONE
MODIFIED CONVENTIONAL WATER FILTRATION PLANTS					
COLIFORM BACTERIA	OVER 20,000 MPN/100 ML	1 PER 100 ML	USUALLY ALUM	20 TO 140 MG/L	PRESEDIMENTATION, PLUS DOUBLE COAGULATION, FLOC. & SETTLING
TURBIDITY	OVER 1,000 TU	1 TU	USUALLY ALUM	20 TO 140 MG/L	PRESEDIMENTATION AND/OR DOUBLE COAGULATION, FLOC. & SETTLING
VIRUS	OVER 1,000 PFU/GALLON	NONE ESTABLISHED	USUALLY ALUM	20 TO 140 MG/L	**ADD**: CL_2 TO 1.0 MG/L FREE RESIDUAL AT POINT ⑦, POLYMER AT POINTS ② & ⑥. ADD PILOT FILTER AT POINT ②. ADD TURBIDITY MONITORS TO EACH FILTER EFFLUENT AND POINT ⑦. USE DUAL OR MIXED MEDIA RATHER THAN SINGLE MEDIA
ARSENIC PENTAVALENT OR TRIVALENT	1.0 MG/L	0.05 MG/L	ALUM OR $FE_2(SO_4)_3$ + pH 7.5	20 TO 30 MG/L	**ADD**: FACILITIES FOR pH ADJUSTMENT AND FOR FEEDING FERRIC SULFATE PREOXIDATION REQUIRED FOR TRIVALENT FORM
ASBESTOS		NONE ESTABLISHED	ALUM	5 TO 140 MG/L	**ADD**: 2 STAGES TO RAPID MIX, POLYMER FEED, PILOT FILTER, MIXED MEDIA IN FILTERS, CONT. TURBIDITY RECORDERS, ADEQUATE BACKWASH, WASHWATER RECOVERY, PROPER SLUDGE DISPOSAL, AND LAB EQUIPMENT FOR ASBESTOS ANALYSIS
CHROMIUM HEXAVALENT	5.0 MG/L	0.05 MG/L	FERROUS SULFATE	5 TO 140 MG/L	**NO** PREDISINFECTION. ADD $FESO_4$ FEEDER AND EQUIPMENT FOR pH ADJUSTMENT TO 6.5 TO 9.3 AT POINT ④
CADMIUM	0.1 MG/L	0.010 MG/L	ALUM OR FERRIC SULFATE	VARIES	**ADD**: FACILITIES FOR pH ADJUSTMENT AT POINT ②. pH 9 FOR ALUM, pH 8 FOR $FE_2(S)_4)_3$
FLUORIDE (Soft Water)	4 TO 6 MG/L	1.4 TO 2.4 MG/L	ALUM	200 TO 500 MG/L	HIGH CAPACITY ALUM FEED PLUS LIME OR CAUSTIC FEED FOR FINAL pH ADJUSTMENT. PROVISION FOR ALUM SLUDGE DISPOSAL
LEAD	1.7 MG/L	0.5 MG/L	ALUM & $FE_2(SO_4)_3$	VARIES	**ADD**: FERRIC SULFATE FEEDER AT POINT ②
MANGANESE, INORGANIC	NONE	0.05 MG/L (SEC. STD)	ALUM & $KMNO_4$	5 TO 140 MG/L 0.3 TO 2.0 MG/L	**ADD**: $KMNO_4$ FEEDER AT POINT ②
MERCURY, INORGANIC	0.006 MG/L	0.002 MG/L	ALUM + pH 7 OR $FE_2(SO_4)_3$ + pH 8 + POWDERED ACT. CARBON (PAC)	VARIES VARIES 5 TO 20 MG/L	**ADD**: FEEDERS FOR FERRIC SULFATE AND PAC AND PROVIDE FOI pH ADJUSTMENT AT POINT ②
MERCURY, ORGANIC	0.02 MG/L	0.002 MG/L	ALUM & PAC	1 MG/L PAC FOR EACH MICROGRAM HG REMOVED	**ADD**: PAC FEEDER AT POINT ②
SELENIUM (QUADRIVALENT)	0.10 MG/L	0.01 MG/L	FERRIC SULFATE	30 MG/L + pH 6.0	**ADD**: FERRIC SULFATE FEEDER AND PROVIDE FOR pH ADJUSTMENT AT POINT ②
SILVER	0.17 MG/L	0.05 MG/L	FERRIC SULFATE	30 MG/L + pH 6 TO 8	**ADD**: FERRIC SULFATE FEEDER AT POINT ②

Figure 6 Flow Diagram and Treatment Alternatives for Conventional Water Treatment

* (National Primary Drinking Water Regulations)

TABLE 11. EQUATION INPUT FACTORS

Item	Value
Power	0.04 \$/kwh
Labor wage rate (DHR)	11.00 \$/hr
Natural gas (NGS)	0.013 \$scf
Diesel fuel (DSL)	1.30 \$/gal
Construction Cost Index (CCI/100)	3.25
Producers Price Index (PPI/100)	2.44
Alum	140 \$/ton
Sodium hydroxide	200 \$/ton
Polymer	4000 \$/ton
Chlorine	300 \$/ton

TABLE 12. DESIGN CRITERIA AND COST CALCULATION FOR A 40 MGD CONVENTIONAL TREATMENT PLANT

Systems and Design Criteria	Design Parameter	Capital Cost ($/yr)	Operating Parameter	Operating Cost ($/yr) (Including chemicals)
Alum Feed - 40 mg/L	500 lb/hr	14454.0	350 lb/hr	241805.2
Sodium Hydroxide Feed System - 15 mg/L	5000 lb/day	11840.6	3300 lb/day	131633.6
Polymer Feed System - 0.2 mg/L	67 lb/day	5986.0	45 lb/day	37916.2
Rapid Mix - 45 sec, G = 600	2785 ft^3	11242.0	2785 ft^3	23199.4
Flocculation - 35 min., G = 50	130,000 ft^3	98988.0	130,000 ft^3	17680.6
Rectangular Clarifiers - 1000 gpd/^{2}	40,000 ft^2 (10 units at 4000 ft^2)	516548.0	40,000 ft^2 (10 units @ 4000 ft^2)	63568.4
Gravity Filtration - 5 gpm/ft^2	5560 ft^2	381352.0	5560 ft^2	87687.6
Filter Media - Mixed Media	5560 ft^2	32996.0	5560 ft^2	0.0
Surface Wash	5560 ft^2	36354.0	5560 ft^2	6949.6
Backwash Pumping - 18 gpm/ft^2	10,010 gpm	28324.0	5560 ft^2	12775.0
Wash Water Surge Basin	200,000 gal	75920.0	200,000 gal	0.0
Chlorine Feed system - 2 mg/L	670 lb/day	16644.0	450 lb/day	39653.6
Clearwell storage - Below Ground	2,500,000 gal	198706.0	2,500,000 gal	0.0
Finished Water Pumping - 220 ft	55 mgd	64094.0	28 mgd	150745.0
Gravity Thickener - 1 Unit	850 ft^2	15476.0	850 ft^2	1737.4
Basket Centrifuge	115,000 gpd	92272.0	70,000 gpd	31579.8
Dewatered Sludge Hauling - 20 miles	20,000 yd^3/yr	18250.0	12,000 mgd	17885
Administrative & Laboratory Maintenance Building	40 mgd	44822.0	40 mgd	122435.6
		1,664,268.6		987,252.0

COMPUTER PROGRAM

A computer program was written to provide the capability for easy cost calculation. To illustrate the use of the program, the following example has been developed.

In the example, two types of treatment systems are hypothesized for turbidity control. One plant is a conventional treatment plant, and the other is a direct filtration plant. Both plants are sized at 100 mgd (378,000 m^3/ day), and the various design assumptions are listed in Tables 13 and 14 as they would appear in the computer listing. The cost of conventional treatment is 13.0 ¢/1000 gal (3.4 ¢/kL) (Table 13) and direct filtration is 10.0 ¢/1000 gal (2.0 ¢/kL) (Table 14). The program, written in Fortran and easily transportable between various machines, is discussed in greater detail in Appendix A. Appendix B, contains a program to calculate cost/quantity relationships.

SUMMARY AND CONCLUSIONS

Cost estimating can serve a number of purposes. Predesign estimates can be used to compare the cost of two treatment plants with similar water treatment goals. These types of estimates can be used to choose the most cost effective treatment alternative. Cost estimating for research can be used to assist in making choices among new and developing technologies and to suggest specific areas for future research. Reliability of cost estimates is important to make proper judgements with regard to the type of basic cost estimate to be considered.

This paper presents a series of cost equations for conventional water treatment unit processes which are accurate to approximately three significant figures. The equations within their level of accuracy can be used for making engineering cost estimates. Examples of this application are presented.

TABLE 13. COST ESTIMATE FOR CONVENTIONAL TREATMENT PLANT*

Process	Flow-MGD Design	Flow-MGD Actual	Process Parameter Design	Process Parameter Operating	Costs-Dollars Constr. ($)	Costs-Dollars Capital ($)	Costs-Cents/1000 gal* O&M	Costs-Cents/1000 gal* Debt	Costs-Cents/1000 gal* Total
Alum Feed-Liquid Stock (30 mg/L)	100,000	70,000	1043.7 lb/hr	730.6 lb/hr	120443.	160591.	1.768	0.059	1.828
Polymer Feed System (0.20 mg/L)	100,000	70,000	166.0 lb/day	116.2 lb/day	37680.	50240.	0.349	0.020	0.369
Rapid Mix = (G = 600)	100,000	70,000	9280.0 cu ft	9280.0 cu ft	160915.	214559.	0.236	0.079	0.315
Flocculation Horizontal (G = 50)	100,000	70,000	185700.0 cu ft	185700.0 cu ft	704116.	938822.	0.092	0.347	0.439
Rectangle Clarifier (units = 3)	100,000	70,000	33330.0 sq ft	33330.0 sq ft	3807421.	5076561.	0.205	1.876	2.080
Gravity Filtration - 2 gpm/ft^2	100,000	70,000	14000.0 sq ft	14000.0 sq ft	3941906.	5255874.	0.568	1.942	2.510
Filtration Media-Mixed	100,000	70,000	14000.0 sq ft	14000.0 sq ft	415922.	554563.	0.000	0.205	0.205
Hydraulic Surface Wash	100,000	70,000	14000.0 sq ft	14000.0 sq ft	423958.	565277.	0.053	0.209	0.262
Backwash Pumping Facilities	100,000	70,000	63000.0 gpm	44100.0 sq ft	494731.	659642.	0.041	0.244	0.335
Wash Water Surge Basin	100,000	70,000	12000000.0 gal	1200000.0 gal	719800.	959734.	0.000	0.355	0.355
CL2 Feed-Cylinder Storage (2.0 mg/L)	100,000	70,000	1680.0 lb/day	1176.0 lb/day	165418.	220558.	0.350	0.081	0.432
Clearwell Storage-Below	100,000	70,000	8000000.0 gal	8000000.0 gal	2592880.	3457174.	0.000	1.277	1.277
Filter Press	100,000	70,000	378.0 cu ft	378.0 cu ft	1403159.	1870879.	0.880	0.691	1.571
Dewatered Sludge Hauling (Miles = 20.0)	100,000	70,000	17000.0 cy/yr	11900.0 mg/yr	84015.	112020.	0.069	0.041	0.111
Administration Build & Lab	100,000	70,000	100.0 mgd	100.0 mgd	391521.	522028.	0.677	0.193	0.070
				TOTAL	15463885.	20618518.	5.340	7.617	12.957

*To convert from ¢/1000 gal to ¢/KL divide by 3.785

TABLE 14. COST ESTIMATE FOR DIRECT FILTRATION PLANT*

Process	Flow-MGD		Process Parameter		Costs-Dollars		Costs-Cents/1000 gal*		
	Design	Actual	Design	Operating	Constr. ($)	Capital ($)	O&M	Debt	Total
Alum Feed-Liquid Stock (15 mg/L)	100.000	70.000	525.0 lb/hr	365.3 lb/hr	82682.	110242.	0.888	0.041	0.929
Polymer Feed System (0.10 mg/L)	100.000	70.000	83.5 lb/day	58.5 lb/day	34354.	45805.	0.182	0.017	0.199
Rapid Mix (G = 600)	100.000	70.000	9280.0 cu ft	9280.0 cu ft	160915.	214554.	0.236	0.079	0.315
Flocculation Horizontal (G = 50)	100.000	70.000	185700.0 cu ft	185700.0 cu ft	704116.	938822.	0.092	0.347	0.439
Gravity Filtration - 2 gpm/ft^2	100.000	70.000	14000.0 sq ft	14000.0 sq ft	3941906.	5255874.	0.568	1.942	2.510
Filtration Media-Mixed	100.000	70.000	14000.0 sq ft	14000.0 sq ft	415922.	554563.	0.000	0.205	0.205
Hydraulic Surface Wash	100.000	70.000	14000.0 sq ft	14000.0 sq ft	423958.	565277.	0.053	0.209	0.262
Backwash Pumping Facilities	100.000	70.000	63000.0 gpm	14000.0 sq ft	494731.	659642.	0.091	0.244	0.335
Wash Water Surge Basin	100.000	70.000	10000000.0 gal	1200000.0 gal	719800.	959734.	0.000	0.355	0.355
CL2 Feed-Cylinder Storage (2.0 mg/L)	100.000	70.000	1680.0 lb/day	1176.0 lb/day	165418.	220558.	0.350	0.081	0.432
Clearwell Storage-Below	100.000	70.000	10000000.0 gal	8000000.0 gal	3053907.	4071876.	0.000	1.504	1.504
Filter Press	100.000	70.000	378.0 cu ft	378.0 cu ft	1403159.	1870879.	0.880	0.691	1.571
Dewatered Sludge Haulting (Miles = 20.0)	100.000	70.000	14000.0 cy/yr	14000.0 mg/yr	82358.	109810.	0.082	0.041	0.122
Administration Build & Lab	100.000	70.000	100.0 mgd	100.0 mgd	391521.	522028.	0.677	0.193	0.870
				TOTAL	12074748.	16099664.	4.100	5.948	10.048

---

*To convert from ¢/1000 gal to ¢/KL divide by 3.785

REFERENCES

1. Gumerman, R. C., Culp, R. L. and Hansen, S. P., Estimating Water Treatment Costs: Volume 2 - Cost Curves Applicable to 1 to 200 mgd Treatment Plants. EPA-600/2/79-162d, MERL, USEPA, Cincinnati, Ohio (Aug. 1979).

2. Hensley, E. F., Consulting Engineer, The Dow Chemical Compnay, Midland, Mich. 48640, in the American Association of Cost Engineers 1967 Symposium on Capital Cost Estimating July 10-12, 1967, Cleveland, Ohio.

3. Chilton, C. H., "Cost Data Correlated", Chemical Engineering, V. 56(6) 1949, pp. 97- .

4. Clark, Loyal, "Cost Estimates Answer Questions", Cost Estimating in the Process Industries, McGraw Hill Book Compnay, Inc., 1960, pp. 1-2.

5. Logsdon, G. L., Clark, R. M., and Tate, Carol H., Direct Filtration Treatment Costs: Costs and Capabilities, JAWWA, Vol. 72, No. 3, March 1980, pp. 134-147.

6. Clark, R. M. and Dorsey P., "The Costs of Compliance: An EPA Estimate for Organics Control" JAWWA, Vol. 72, No. 8, August 1980, pp. 450-457.

7. Uhl, Vincent W., A. Standard Procedure for Cost Analysis of Pollutional Control Operations: Volume 1. Users Guide. EPA-600/8-79-018a, IERL, USEPA, Research Triangle Park, North Carolina, 27711.

8. Lineck, Thomas S., Gumerman, Robert C., and Culp, Russell L., Estimating Water Treatment Costs: Volume 4 - Computer Users Manual for Retrieving and Updating Cost Data, EPA-600/2-79-162d, MERL, USEPA, Cincinnati, Ohio (Aug. 1979).

APPENDIX A - COMPUTER USER'S GUIDE FOR COST EQUATIONS

In order to facilitate the use of the empirical cost equations shown in this report, a computer program was written and described in this section. This user's guide contains the program Fortran listings along with the necessary data files needed to operate the program. The Fortran listing is called CWC.FTN associated data files, which are shown in subsequent figures, are PROCES.DAT, INDEX.DAT, VARY.DAT, CWC.DAT, AND CWC1.DAT.

Figure A-1 shows CWC.FTN, a listing of the Fortran computer program used in this report. Figure A-2 shows CWC1.DAT which is the data file that contains all the equations for the smaller plant sizes. Included in the information given in Figure A-2 for each unit process is the process name, the Capital and and Operations equations ranges, the Capital equation parameters, and Operating and Maintenance equation parameters. For example, the first line in Figure A-2 gives the process name, followed by the capital and O&M ranges separated by commas. The second line consists of the O&M equation parameters which are the following variables: Constant,USRT,POWER,WPI,and DHR coefficients. The third line contains similar information for Capital equation variables: Constant, USRT, and CCI coefficients. All the other processes follow the same type of formatting except for differences in variable parameters. Figure A-3 illustrates CWC.DAT which contains the equations for the large range equations. The format of the data file CWC1.DAT is the same as for CWC.DAT. The INDEX.DAT file in Figure A-4 contains all default cost values and indices. At no time should any data field in this file be left blank because a blank data field would cause an execution of the program to give a misleading answer of zeros for each process cost.

FIGURE A-1 - FORTRAN LISTING

```
      COMMON /A/ DAPV(20),OOPV(20),ACOST(20),OCOST(20),DXU,OXU
     1,PROCES(4)
      COMMON /B/ C(3),D(3),E(3),F(3),GA(3),H(3),OPV,PROEN(30),MAINT(30)
     1,LABOR(30),BLDEN(30),DESL(30),NGAS(30),MILES,TDH,G,OM1,ITYPE,NR,
     2POWER,DHR,DIESL,NTGAS
      COMMON /C/ FACTOR(8),CONST,EXC(30),MANEQ(30),CONCR(30),
     1STEEL(30),LABR(30),PIPE(30),ELEC(30),HUSING(30)
      COMMON /D/ NP,I
      DIMENSION A(9),B(6),RN(50),CMNAM(6,10),COPV(10),CPV(10),COST(10),
     1TCHEM(10),CAMT(10),ACAP(10),AOM(10),CCHEM(10)
      DIMENSION ACHEM(30)
      DOUBLE PRECISION PROCES,DXU,OXU,CMNAM,OUTPUT,CTSGAL,PRINT,DETAIL
      REAL NTGAS,OM,OLOW,OUP,MILES,OPV,NC,NCHEM,MULT,MAINT,LABOR,LABR,
     1,NGAS,MANEQ
      DATA CTSGAL,DETAIL/'CTSGAL','DETAIL'/
      INTEGER TYPE,R
      YRS=20.
      FACTR=.1018522
      OPEN(UNIT=1,NAME='CWC.DAT',TYPE='OLD',ACCESS='DIRECT',
     1FORM='FORMATTED',RECORDSIZE=80)
      OPEN(UNIT=2,NAME='CWC1.DAT',TYPE='OLD',ACCESS='DIRECT',
     1FORM='FORMATTED',RECORDSIZE=80)
      OPEN(UNIT=3,NAME='INDEX.DAT',TYPE='OLD')
      OPEN(UNIT=4,NAME='PROCES.DAT',TYPE='OLD')
      OPEN(UNIT=7,NAME='VARY.DAT',TYPE='OLD')
      OPEN(UNIT=8,NAME='TOM.DAT',TYPE='NEW')
      DO 3000 NO=1,30
      TCAP=0.
      TOM=0.
      TCOST=0.0
      CTSTOM=0.0
      SUM1=0.0
      SUM2=0.0
      SUM3=0.0
      DSUM1=0.0
      NR=0.0
      DSUM2=0.0
      DSUM3=0.0
      IF(NO.EQ.1.AND.NI.GT.1)REWIND 7
      READ(7,102,END=3000)RN(NO)
      DO 25 I=1,99
      REWIND 3
      READ(3,101)POWER,DHR,WPI,NTGAS,DIESL,CCI,CON,PRCENT,RI,
     1TDH,UNITS,MILES,G,NC
      READ(3,105)OUTPUT,PRINT
```

FIGURE A-1 - FORTRAN LISTING (Cont'd)

```
      IO=1
      TEST4=0.0
      IF(NO.GT.1.AND.I.EQ.1)REWIND 4
      IF(NC.EQ.1)POWER=RN(NO)
      IF(NC.EQ.2)DHR=RN(NO)
      IF(NC.EQ.3)WPI=RN(NO)
      IF(NC.EQ.4)NTGAS=RN(NO)
      IF(NC.EQ.5)DIESL=RN(NO)
      IF(NC.EQ.6)CCI=RN(NO)
      IF(NC.EQ.7)CON=RN(NO)
      IF(NC.EQ.8)PRCENT=RN(NO)
      IF(NC.EQ.9)RI=RN(NO)
      IF(NC.EQ.11)MULT=RN(NO)
      IF(NC.EQ.12)MULT=RN(NO)
      TCHEM(I)=0.0
      READ(4,110,END=1000) NP
      READ(4,100)QP,QD,DPV,OPV,CHAR
      IF(NC.EQ.12)READ(4,120)A1LOW,A1UP,O1LOW,O1UP
  120 FORMAT(4F)
      IF(NC.NE.11)MULT=QP
      Q1=QP
      QP=QP/Q1
      QP=QP*MULT
      QD=QD/Q1
      QD=QD*MULT
      DPV=DPV/Q1
      DPV=DPV*MULT
      OPV=OPV/Q1
      OPV=OPV*MULT
      N=CHAR
      POWER1=POWER
      IF(NP.EQ.89)POWER=CON
      IF(NP.EQ.90.OR.NP.EQ.91)G=MILES
      IF(NP.EQ.92.OR.NP.EQ.93.OR.NP.EQ.57)G=TDH
      IF(NP.EQ.71)PRCENT=MILES
      IZ=1+(NP-1)*3
      R=0.0
    5 READ(IO 'IZ,10) TYPE,(PROCES(L),L=1,4),ALOW,AUP,OLOW,OUP,ITYPE
      READ(IO 'IZ+1,13) A,DXU
      READ(IO 'IZ+2,15) B,OXU
      R=R+1
      IF(R.GT.2)GO TO 140
      IF(ITYPE.NE.0)N=0
      IF(NC.NE.10.AND.NC.NE.12.OR.I.GT.1)GO TO 54
      IF(IO.EQ.1)DPV1=DPV
      DPV=DPV1/RN(1)
```

FIGURE A-1 - FORTRAN LISTING (Cont'd)

```
      DPV=DPV*RN(NO)
      IF(IO.EQ.1)OPV1=OPV
      OPV=OPV1/RN(1)
      OPV=OPV*RN(NO)
      ARANGE=A1UP-A1LOW
      ORANGE=O1UP-O1LOW
      IF(NC.EQ.12)DPV=ARANGE*RN(NO)+A1LOW
      DAPV(NO)=DPV
      IF(NC.EQ.12)OPV=ORANGE*RN(NO)+O1LOW
      OOPV(NO)=OPV


   54 IF(N.EQ.0.OR.ITYPE.EQ.4.OR.NP.EQ.71)GO TO 6
      DO 1 L=1,N
      IF(IO.EQ.1)READ(4,103)COPV(L),COST(L),(CMNAM(L,LO),LO=1,3)
      IF(IO.EQ.1)CPV(L)=COPV(L)
      IF(NC.NE.10.OR.I.GT.1)GO TO 55
      COPV(L)=CPV(L)/RN(1)
      COPV(L)=COPV(L)*RN(NO)
   55 IF(OXU.EQ.'LB/DAY')CAMT(L)=COPV(L)*365./2000.
      CAMT(L)=COPV(L)*QD*8.35*365./2000.
      TCHEM(L+1)=CAMT(L)*COST(L)+TCHEM(L)
      CHEM=TCHEM(L+1)
      ACHEM(L)=CAMT(L)*COST(L)
    1 CONTINUE
      CCHEM(I)=CHEM
    6 IF(ITYPE.EQ.1)G=CHAR
      IF(N.EQ.0)CHEM=0.0
      IF(ITYPE.EQ.2)G=CHAR
      IF(ITYPE.EQ.2)MILES=CHAR
      IF(ITYPE.EQ.3)G=CHAR
      IF(ITYPE.EQ.3)TDH=CHAR
      IF(ITYPE.EQ.4.OR.ITYPE.EQ.5)UNITS=CHAR
      IF(NP.EQ.71)PRCENT=CHAR
      IF(NP.EQ.71)MILES=CHAR
      AF=RI*(1.+RI)**YRS/((1.+RI)**YRS-1.)
      TEST=OPV-OLOW
      TEST1=DPV-ALOW
      TEST2=OUP-OPV
      TEST3=AUP-DPV
      IF(TEST2.LT.0.AND.IO.EQ.1)GO TO 140
      IF(TEST3.LT.0.AND.IO.EQ.1)GO TO 140
      GO TO 40
  150 IO=2
      GO TO 5
  140 TEST4=1.0
```

FIGURE A -1 - FORTRAN LISTING (Cont'd)

```
   30 FORMAT(2X,/,' OPERATING OR CAPITAL PARAMETER OUTSIDE OF EQUATION
     1RANGE>',4A8,/)
   10 FORMAT(I2,4A8,4F,I1)
   13 FORMAT (9F,A6)
   15 FORMAT(6F,A6,F)
    3 FORMAT(1X,4A8)
   40 IF(ITYPE.NE.0.AND.ITYPE.NE.4)GO TO 50
      AOM(R)=A(1)*OPV**A(2)*POWER**A(3)*WPI**A(4)*DHR
     1**A(5)*NTGAS**A(6)*DIESL**A(7)*UNITS**A(8)
     2*PRCENT**A(9)
      IF(TEST.GE.0.AND.TEST2.GE.0)OM1=AOM(R)
      IF(TEST2.LT.0.AND.IO.EQ.1)OM1=AOM(1)
      IF(IO.EQ.2.AND.TEST.LT.0)OM1=AOM(2)
      ACAP(R)=B(1)*DPV**B(2)*CCI**B(3)*UNITS**B(4)*PERCENT**B(5)
      IF(TEST1.GE.0.AND.TEST3.GE.0)CAP=ACAP(R)
      IF(TEST3.LT.0.AND.IO.EQ.1)CAP=ACAP(1)
      IF(TEST1.LT.0.AND.IO.EQ.2)CAP=ACAP(2)
      TOTCAP=CAP/FACTR
      CAP=TOTCAP*AF
      CONST=.75*CAP/AF
      CAPITL=CAP/AF
      IF(TEST4.EQ.1)GO TO 35
      IF(TEST.LT.0)GO TO 150
      IF(TEST1.LT.0)GO TO 150
      GO TO 35
   50 AOM(R)=A(1)*OPV**A(2)*POWER**A(3)*WPI**A(4)*DHR
     1**A(5)*NTGAS**A(6)*DIESL**A(7)*UNITS**A(8)*A(9)**G
      IF(TEST.GE.0.AND.TEST2.GE.0)OM1=AOM(R)
      IF(TEST2.LT.0.AND.IO.EQ.1)OM1=AOM(1)
      IF(IO.EQ.2.AND.TEST.LT.0)OM1=AOM(2)
      ACAP(R)=B(1)*DPV**B(2)*CCI**B(3)*UNITS**B(4)*B(5)**G
      IF(TEST1.GE.0.AND.TEST3.GE.0)CAP=ACAP(R)
      IF(TEST3.LT.0.AND.IO.EQ.1)CAP=ACAP(R)
      IF(TEST1.LT.0.AND.IO.EQ.2)CAP=ACAP(R)
      TOTCAP=CAP/FACTR
      CAP=TOTCAP*AF
      CONST=.75*CAP/AF
      CAPITL=CAP/AF
      IF(TEST4.EQ.1)GO TO 35
      IF(TEST.LT.0)GO TO 150
      IF(TEST1.LT.0.)GO TO 150
   35 CONTINUE
      IF(PRINT.EQ.DETAIL)CALL MARK
      IF(PRINT.EQ.DETAIL)CALL MARK1
      OCOST(NO)=OM1
      ACOST(NO)=CONST
      TCAP=TCAP+CAPITL
      OM=OM1+CHEM
```

FIGURE A-1 - FORTRAN LISTING (Cont'd)

```
      CTSTOM=OM/(3650*QD)
      CTSDEB=CAP/(3650*QD)
      CTSTL=CTSTOM+CTSDEB
      DEB=CAP/1000.
      DOM=OM/1000.
      TCOST=TCOST+CONST
      SUM1=SUM1+CTSTOM
      TOTAL=DEB+DOM
      DSUM1=DSUM1+DOM
      SUM2=SUM2+CTSDEB
      DSUM2=DSUM2+DEB
      SUM3=SUM3+CTSTL
      DSUM3=DSUM3+TOTAL
   36 IF(I.EQ.1)WRITE(6,301)
   38 FORMAT(2X,'RANGE FOR CAPITAL EQUATION IS=',F12.1,2X,'TO'
     1,2X,F12.1)
   39 FORMAT(2X,'RANGE FOR O&M EQUATION IS',F12.1,2X,'TO',2X,F12.1)
  301 FORMAT('1',//,T44,'COST SUMMARY FOR WATER TREATMENT PROCESSES',//)
      IF(OUTPUT.NE.CTSGAL)GO TO 400
      IF(I.EQ.1)WRITE(6,302)
  400 IF(I.EQ.1.AND.OUTPUT.NE.CTSGAL)WRITE(6,401)
  401 FORMAT(T17,'PROCESS'T42,'FLOW-MGD'T64,'PROCESS PARAMETER'
     1T94,'COSTS-DOLLARS'T113,'COSTS-THOUS. DOL/YR'/,T40,'DESIGN
     2 ACTUAL'T61,'DESIGN'T76,'OPERATING'T92,'CONSTR','     CAPITAL'
     3T113,'O&M    DEBT    TOTAL'/)
  302 FORMAT(T17,'PROCESS'T42,'FLOW-MGD'T64,'PROCESS PARAMETER'
     1T94,'COSTS-DOLLARS'T114,'COSTS-CTS/1000 GAL'/,T40,'DESIGN
     2 ACTUAL'T61,'DESIGN'T76,'OPERATING'T92,'CONSTR','     CAPITAL'
     3T113,'O&M    DEBT    TOTAL'/)
      IF(OUTPUT.NE.CTSGAL)GO TO 402
      WRITE(6,303)I,(PROCES(L),L=1,4),QP,QD,DPV,DXU,OPV,OXU,CONST,
     1CAPITL,CTSTOM,CTSDEB,CTSTL
      GO TO 450
  402 WRITE(6,403)I,(PROCES(L),L=1,4),QP,QD,DPV,DXU,OPV,OXU,CONST,
     1CAPITL,DOM,DEB,TOTAL
  450 IF(ITYPE.EQ.1.OR.ITYPE.EQ.5)WRITE(6,307)G
  307 FORMAT(4X,'G FACTOR  =',F5.0)
      IF(ITYPE.EQ.2.OR.NP.EQ.71)WRITE(6,308)MILES
  308 FORMAT(4X,'DISTANCE IN MILES =',F6.1)
      IF(ITYPE.EQ.3)WRITE(6,309)TDH
  309 FORMAT(4X,'TOTAL DYNAMIC HEAD =',F6.1)
      IF(ITYPE.EQ.4.OR.ITYPE.EQ.5)WRITE(6,310)UNITS
      IF(NP.EQ.72)WRITE(6,312)PRCENT
      IF(NP.EQ.89)WRITE(6,313)CON
```

FIGURE A-1 - FORTRAN LISTING (Cont'd)

```
      IF(N.EQ.0.OR.ITYPE.NE.0.OR.NP.EQ.71) GO TO 2
  310 FORMAT(4X,'TOTAL NUMBER OF UNITS OR CONTACTORS ='F5.0)
      DO 2 L=1,N
      WRITE(6,346)COST(L),(CMNAM(L,LO),LO=1,3)
      WRITE(6,341)CAMT(L)
      IF(OUTPUT.NE.CTSGAL)WRITE(6,340)(CMNAM(L,LO),LO=1,3),ACHEM(L)
      WRITE(6,345)COPV(L)
  340 FORMAT(4X,'COST FOR ',3A6,T30,'=',F8.1,' $/YEAR')
  341 FORMAT(4X,'FEED RATE',T30,'=',F6.0,'TONS/YR.')
  346 FORMAT(/,4X,F8.2,'$/TON OF',1X,3A6)
  345 FORMAT(4X,'CHEMICAL DOSAGE' ,T30,'=',F9.2,' MG/L')
    2 CONTINUE
  312 FORMAT(2X,'PERCENT OF OWNERSHIP ='F5.0)
  313 FORMAT(2X,'CONCENTRATION LEVEL ='F5.0)
  303 FORMAT(1X,I2,1X,4A8,2F8.3,F11.1,1X,A6,F10.1,1X,A6,F10.0,F11.0,
     13F8.3)
  403 FORMAT(1X,I2,1X,4A8,2F8.3,F11.1,1X,A6,F10.1,1X,A6,F10.0,F11.0,
     13F8.1)
    4 CONTINUE
   37 IF(TEST4.EQ.1)WRITE(6,30) (PROCES(L),L=1,4)
      IF(TEST4.NE.1) GO TO 25
      IF(TEST.LT.0.OR.TEST2.LT.0) WRITE(6,39)OLOW,OUP
      IF(TEST1.LT.0.OR.TEST3.LT.0)WRITE(6,38)ALOW,AUP
  100 FORMAT(5F,3A6)
  101 FORMAT(//13(40X,F10.0/),40X,2F)
  102 FORMAT(F)
  103 FORMAT(2F,3A6)
  104 FORMAT(2F,3A6)
  105 FORMAT(40X,A8,/,40X,A8)
  110 FORMAT(I)
   25 CONTINUE
 1000 IF(OUTPUT.EQ.CTSGAL)WRITE(6,304)TCOST,TCAP,SUM1,SUM2,SUM3
 1001 IF(OUTPUT.NE.CTSGAL)WRITE(6,304) TCOST,TCAP,DSUM1,DSUM2,DSUM3
      IF(PRINT.NE.DETAIL)GO TO 1200
  304 FORMAT(T87,46('_'),//,T82,'TOTAL'T88,F10.0,F11.0,
     13F8.3)
      WRITE(6,317)
  317 FORMAT(///,T36,'OPERATING  AND  MAINTENANCE BREAKDOWN SUMMARY',//)
      WRITE(6,318)
  318 FORMAT(T7,'PROCESS',T31,'MAINTENANCE',T53,'LABOR',T71,'BUILDING',
     1T92,'DIESEL',T111,'NATURAL',T122,'CHEMICALS',/,T7,'ENERGY',T32,
     2'MATERIAL',T72,'ENERGY',T92,'FUEL',T113,'GAS',/,T7,'(KWH/YR)',T32,
     3'($/YR)',T54,'(HR/YR)',T71,'(KWH/YR)',T91,'(GAL/YR)',T111,'(SCF/YR
     4)',T124,'($/YR)')
      DO 1100 I=1,NR
      WRITE(6,320)I,PROEN(I),MAINT(I),LABOR(I),BLDEN(I),DESL(I),
     1NGAS(I),CCHEM(I)
  320 FORMAT(T3,I2,T7,F10.0,T31,F10.0,T51,F9.0,T71,F9.0,T91,F9.0,
     1T111,F10.0,T121,F10.0)
 1100 CONTINUE
```

FIGURE A-1 - FORTRAN LISTING (Cont'd)

```
      WRITE(6,321)
  321 FORMAT(//,T37,'CONSTRUCTION  COST  ITEMIZATION  IN TOTAL DOLLARS'
     1,//)
      WRITE(6,322)
  322 FORMAT(T7,'EXCAVATION',T26,'MANUFACTURED',T43,'CONCRETE',T58,'STE
     1EL',T74,'LABOR',T89,'PIPE &',T107,'ELECTRICAL &',T124,'HOUSING',/,
     2T27,'EQUIPMENT',T89,'VALVES',T107,'INSTRUMENTATION')
      DO 1200 I=1,NR
      WRITE(6,323)I,EXC(I),MANEQ(I),CONCR(I),STEEL(I),LABR(I),PIPE(I),
     1ELEC(I),HUSING(I)
  323 FORMAT(T3,I2,T7,F9.0,T26,F8.0,T43,F8.0,T56,F8.0,T71,F8.0,T88,
     1F8.0,T106,F8.0,T124,F8.0)
 1200 CONTINUE
  305 FORMAT(T87,46('_'),//,T82,'TOTAL'T88,F10.0,F11.0,
     13F8.1)
      WRITE(6,306)POWER1,DHR,DIESL,NTGAS,WPI,CCI
  306 FORMAT(///,T58,'UNIT COST FACTORS'//,T47,'ELECTRICITY, $/KWH',
     1T80,'=',F6.2,/,T47,'LABOR, $/HR',T80,'=',F6.2,/,T47,'DIESEL
     2FUEL, $/GAL',T80,'=',F6.3,/,T47,'NATURAL GAS, $/CU FT',T80
     6,'=',F6.4,/,T47,'WHOLESALE PRICE INDEX',T80,'=',F7.2,/,T47,
     4'CONST. COST INDEX',T80,'=',F6.2)
      WRITE(6,311)YRS,RI
      IF(NC.EQ.0)GO TO 200
  350 FORMAT(6F13.2)
  311 FORMAT(T47,'AMORTIZATION PERIOD,'T80,'=',F6.2,/,T47,'INTEREST
     1 RATE(%)',T80,'=',F6.2)
      WRITE(8,408) (PROCES(L),L=1,4)
  408 FORMAT(2X,'THIS PROCESS NAME IS =',4A8)
      WRITE(8,407) DAPV(NO),ACOST(NO),OOPV(NO),OCOST(NO)
  407 FORMAT(///,4F10.0)
 3000 CONTINUE
      CLOSE(UNIT=1)
      IF(NC.EQ.12)CALL PLOT1
 4000 CONTINUE
  200 END
      SUBROUTINE MARK
      COMMON /B/ C(3),D(3),E(3),F(3),GA(3),H(3),OPV,PROEN(30),MAINT(30)
     1,LABOR(30),BLDEN(30),DESL(30),NGAS(30),MILES,TDH,G,OM1,ITYPE,NR,
     2POWER,DHR,DIESL,NTGAS
      COMMON /D/ NP,I
      REAL MAINT,LABOR,NGAS,MILES,OPV,LCOST
      DOUBLE PRECISION PROCES(4)
      CLOSE(UNIT=1)
      OPEN(UNIT=1,NAME='QUANT.DAT',TYPE='OLD',ACCESS='DIRECT',
     1FORM='FORMATTED',RECORDSIZE=80)
      IZ=1+(NP-1)*3
```

FIGURE A-1 - FORTRAN LISTING (Cont'd)

```
      READ(1'IZ,10)(PROCES(L),L=1,4)
      READ(1'IZ+1,20) C,D,E
      READ(1'IZ+2,30) F,GA,H
   10 FORMAT(4A8)
   20 FORMAT(3F,3F,3F)
   30 FORMAT(3F,3F,3F)
      NR=NR+1
      IF(ITYPE.EQ.1)X=G
      IF(ITYPE.EQ.2)X=MILES
      IF(ITYPE.EQ.3)X=TDH
      IF(C(3).EQ.0)C(3)=1.
      IF(D(3).EQ.0)D(3)=1.
      IF(E(3).EQ.0)E(3)=1.
      IF(F(3).EQ.0)F(3)=1.
      IF(GA(3).EQ.0)GA(3)=1.
      IF(H(3).EQ.0)H(3)=1.
      PROEN(I)=C(1)*(OPV**C(2))*(C(3)**X)
      MAINT(I)=D(1)*(OPV**D(2))*(D(3)**X)
      LABOR(I)=E(1)*(OPV**E(2))*(E(3)**X)
      BLDEN(I)=F(1)*(OPV**F(2))*(F(3)**X)
      DESL(I)=GA(1)*(OPV**GA(2))*(GA(3)**X)
      NGAS(I)=H(1)*(OPV**H(2))*(H(3)**X)
      IF(NP.EQ.71)PROEN(I)=C(1)*(OPV**C(2))*(MILES**C(3))
      IF(NP.EQ.71)MAINT(I)=D(1)*(OPV**D(2))*(MILES**D(3))
      IF(NP.EQ.71)LABOR(I)=E(1)*(OPV**E(2))*(MILES**E(3))
      IF(NP.EQ.71)BLDEN(I)=F(1)*(OPV**F(2))*(MILES**F(3))
      IF(NP.EQ.71)DESL(I)=GA(1)*(OPV**GA(2))*(MILES**GA(3))
      IF(NP.EQ.71)NGAS(I)=H(1)*(OPV**H(2))*(MILES**H(3))
      PCOST=PROEN(I)*POWER
      LCOST=LABOR(I)*DHR
      BECOST=BLDEN(I)*POWER
      DECOST=DESL(I)*DIESL
      NGCOST=NGAS(I)*NTGAS
      OM1=PCOST+LCOST+MAINT(I)+BECOST+DECOST+NGCOST
      RETURN
      END
      SUBROUTINE MARK1
      COMMON /C/ FACTOR(8),CONST,EXC(30),MANEQ(30),CONCR(30),
     1STEEL(30),LABR(30),PIPE(30),ELEC(30),HUSING(30)
      COMMON /D/ NP,I
      DOUBLE PRECISION PROCES(4)
      REAL MANEQ,LABR
```

FIGURE A-1 - FORTRAN LISTING (Cont'd)

```
      CLOSE(UNIT=1)
      OPEN(UNIT=1,NAME='CONST.DAT',TYPE='OLD',ACCESS='DIRECT',
     1FORM='FORMATTED',RECORDSIZE=80)
      IZ=1+(NP-1)*2
      READ(1'IZ,10) (PROCES(L),L=1,4)
      READ(1'IZ+1,20) FACTOR
   10 FORMAT(4A8)
   20 FORMAT(8F)
      EXC(I)=FACTOR(1)*CONST
      MANEQ(I)=FACTOR(2)*CONST
      CONCR(I)=FACTOR(3)*CONST
      STEEL(I)=FACTOR(4)*CONST
      LABR(I)=FACTOR(5)*CONST
      PIPE(I)=FACTOR(6)*CONST
      ELEC(I)=FACTOR(7)*CONST
      HUSING(I)=FACTOR(8)*CONST
      CLOSE(UNIT=1)
      OPEN(UNIT=1,NAME='CWC.DAT',TYPE='OLD',ACCESS='DIRECT',
     1FORM='FORMATTED',RECORDSIZE=80)
      RETURN
      END
```

FIGURE A-2 - CWC1.DAT

```
00 CL2 FEED-CYLINDER STORAGE       10.,1000.,10.,300.
1506.12,.105,.078,.273,.589,,,,,LB/DAY
157.27,.495,.987,,,,LB/DAY
00 CL2 FEED-ON SITE STORAGE TANK     2000.,10000.,2000.,10000.
430.25,.272,0.,.370,.521,,,,,LB/DAY
90.60,.5782,1.003,,,,LB/DAY
00 CL2 FEED FROM RAIL CAR            2000.,10000.,2000.,10000.
611.58,.221,.029,.4655,.468,,,,,LB/DAY
1035.48,.262,.991,,,,LB/DAY
00 CHLORINE DIOXIDE GENERATING        10.,500.,10.,100.
1344.75,.143,.065,.205,.653,,,,,LB/DAY
783.07,.277,.993,,,,LB/DAY
00 OZONE GENERATION SYSTEMS             10.,700.,10.,100.
4884.3,.489,.463,.154,.292,,,,,LB/DAY
768.65,.581,1.0068,,,,LB/DAY
00 OZONE CONTACT CHAMBER              400.,46.E03,460.,92000.
0.0,0.0,0.0
15.55,.538,.932,,,,CU FT
00 ON-SITE HYPOCHLORITE GENERATION      10.,750.,10.,100.
1461.94,.362,.263,.197,.452,,,,,LB/DAY
66.63,.815,.998,,,,LB/DAY
00 ALUM FEED-LIQUID STOCK,              5.4,100.,5.4,100.
1055.6, .121, .418, .065, .441,,,,,LB/HR
753.27,.177,.993,,,,LB/HR
00 ALUM FEED-DRY STOCK,               10.,100.,10.,500.
369.02,.347,.201,.037,.694,,,,,LB/HR
709.33,.2177,.994,,,,LB/HR
00 POLYMER FEED SYSTEM,             1.,10.,1.,200.
2014.98,.0533,.294,.1037,.537,,,,,LB/DAY
949.92,0.0,.998,,,,LB/DAY
00 LIME FEED-NO RECALCINATION,         10.,1000.,10.,100.
980.42,.2399,.104,.0938,.728,,,,,LB/HR
1532.75,.188,.995,,,,LB/HR
00 LIME FEED-WITH RECALCINATION,       1000.,10000.,1000.,10000.
143.49,.466,.052,.038,.8946,,,,,LB/HR
663.60,.236,.994,,,,LB/HR
00 POTASSIUM PERMANGANATE FEED,        1.,10.,1.,10.
401.15, .0488, .078, .035, .858,,,,,LB/DAY
435.7,.1295,.998,,,,LB/DAY
00 SULFURIC ACID FEED SYSTEMS,         10.,100.,10.,500.
76.97,.188,0.0,0.0,.8316,,,,,GPD
300.,.10155,.997,,,,GPD
00 SODIUM HYDROXIDE FEED SYSTEMS,      10.,1000.,10.,1000.
389.34,.028,.132,.1027,.717,,,,,LB/DAY
673.33,.082,.995,,,,LB/DAY
00 FERROUS SULFATE FEED SYSTEMS,       10.,400.,10.7,400.
```

FIGURE A-2 - CWC1.DAT (Cont'd)

```
30.,.823,.136,0.0,.522,,,,,LB/HR
692.66,.2045,.9941,,,,LB/HR
00 FERRIC SULFATE FEED SYSTEMS,       10.,400.,13.,400.
698.41,.158,.1478,0.0,.704,,,,,LB/HR
285.99,.389,.987,,,,LB/HR
00 ANHYDROUS AMMONIA FEED FAC.,          250.,5000.,250.,5000.
401.86,.3235,.07005,.414,.461,,,,,LB/DAY
217.89,.391,1.0,,,,LB/DAY
00 AQUA AMMONIA FEED FACILITY,       255.,5000.,255.,1000.
112.230,.08977,0.0,.1273,.854,,,,,LB/DAY
63.09,.431,.999,,,,LB/DAY
00 POWDERED ACTIVATED CARBON FEED,   3.5,100.,3.5,350.
3198.6,.425,.291,.206,.381,,,,,LB/HR
2552.,.1578,.9952,,,,LB/HR
00 RAPID MIX(G=60,90,    120),        100.,1000.,100.,1000.,1
342.5,.3523,.364,0.,.581,0.0,0.0,0.0,1.00129,CU FT
180.18,.27056,.9927,0.0,1.0004375,,CU FT
00 RAPID MIX(G=60,90,    120),        100.,1000.,100.,1000.,1
342.5,.3523,.364,0.,.581,0.0,0.0,0.0,1.00129,CU FT
180.18,.27056,.9927,0.0,1.0004375,,CU FT
00 RAPID MIX(G=60,90,    120),        100.,1000.,100.,1000.,1
342.5,.3523,.364,0.,.581,0.0,0.0,0.0,1.00129,CU FT
180.18,.27056,.9927,0.0,1.0004375,,CU FT
00 FLOCCULATION HORIZONTAL            1800.,10000.,1800.,30000.,1
17.79,.449,.197,.2936,.435,0.0,0.0,0.0,1.00916,CU FT
97.97,.39166,.9947,0.0,1.001544,,CU FT
00 FLOCCULATION HORIZONTAL            1800.,10000.,1800.,30000.,1
17.79,.449,.197,.2936,.435,0.0,0.0,0.0,1.00916,CU FT
97.97,.39166,.9947,0.0,1.001544,,CU FT
00 FLOCCULATION HORIZONTAL            1800.,10000.,1800.,30000.,1
17.79,.449,.197,.2936,.435,0.0,0.0,0.0,1.00916,CU FT
97.97,.39166,.9947,0.0,1.001544,,CU FT
00 FLOCCULATION-VERTICAL                1800.,25000.,1800.,25000.,1
21.82,.411,.148,.313,.439,0.0,0.0,0.0,1.0084, CU FT
23.63,.581,1.0086,0.0,,CU FT
00 FLOCCULATION-VERTICAL                1800.,25000.,1800.,25000.,1
21.82,.411,.148,.313,.439,0.0,0.0,0.0,1.0084, CU FT
23.63,.581,1.0086,0.0,,,CU FT
00 FLOCCULATION-VERTICAL                1800.,25000.,1800.,25000.,1
21.82,.411,.148,.313,.439,0.0,0.0,0.0,1.0084, CU FT
23.63,.581,1.0086,0.0,,CU FT
00 CIRCULAR CLARIFIER-LIME         707.,1000.,707.,1590.,4
90.17,.253,.092,.182,.682,,,1.006,,SQ FT
```

FIGURE A-2 - CWC1.DAT (Cont'd)

```
473.82,.340,.9998,,,,SQ FT
00 CIRCULAR CLARIFIER-FECL3       707.,1000.,707.,1590.,4
71.18,.260,.064,.189,.709,,,1.0059,,SQ FT
473.82,.340,.9998,,,,SQ FT
00 RECTANGLE CLARIFIER-LIME         240.,4800.,240.,600.,4
148.04,.184,.057,.156,.747,,,1.005,,SQ FT
36.09,.701,.993,1.00047,,,SQ FT
00 RECTANGLE CLARIFIER-FECL3       240.,4800.,240.,600.,4
149.1,.181,.056,.1566,.748,,,1.005,,SQ FT
36.09,.701,.993,1.00047,,,SQ FT
00 UPFLOW SOLIDS CONTACT CLAR       255.,14500.,255.,2500.,5
300.76,.261,.155,.134,.654,1.0052,1.001959,,SQ FT
186.70,.5117,1.009,1.0,,SQ FT
00 UPFLOW SOLIDS CONTACT CLAR       255.,14500.,255.,2500.,5
300.76,.261,.155,.134,.654,1.0052,1.001959,,SQ FT
186.70,.5117,1.009,1.0,,SQ FT
00 UPFLOW SOLIDS CONTACT CLAR       255.,14500.,255.,2500.,5
300.76,.261,.155,.134,.654,1.0052,1.001959,,SQ FT
186.70,.5117,1.009,1.0,,SQ FT
00 TUBE SETTLING MODULES           280.,56000.,280.,56000.
0.0,0.0
2.9324,.9087,1.001,,,,SQ FT
00 GRAVITY FILTRATION               140.,5000.,140.,1000.
511.22,.479,.236,.111,.589,,,,,SQ FT
456.92,.5787,.9937,,,,SQ FT
00 FILTRATION MEDIA-RAPID SAND       350.,3500.,1000.,74800.
0.0,0.0
4.00,.732,.993,,,,SQ FT
00 FILTRATION MEDIA-DUAL             140.,2000.,140.,1000.
0.0,0.0
8.06,.741,.995,,,,SQ FT
00 FILTRATION MEDIA-MIXED            140.,1000.,140.,1000.
0.0,0.0,0.0
13.083,.72,.9945,,,,SQ FT
00 BACKWASH PUMPING FACILITIES      1260.,28000.,1537.,4000.
74.04,.607,.3205,.307,.283,,,,,GPM
29.95,.590,.966,,,,SQ FT
00 HYDRAULIC SURFACE WASH            140.,700.,140.,2000.
49.25,.475,.243,.128,.544,,,,,SQ FT
284.13,.284,.9959,,,,SQ FT
00 AIR-WATER BACKWASH FACILITIES      140.,600.,140.,2000.
209.11,.368,.192,.303,.424,,,,,SQ FT
1447.84,.1619,.998,,,,SQ FT
00 WASH WATER SURGE BASIN            10000.,100000.,10000.,500000.
```

FIGURE A-2 - CWC1.DAT (Cont'd)

```
0.0,0.0
2.70,.723,1.00156,,,,GAL
00FILTER MOD-RAP SAND TO HIGH RATE     100.,28000.,100.,28000
0.0,0.0,0.0
31.08,.656,.984,,,,SQ FT
00CONTINUOUS AUTO. BACKWASH FILTER  360.,3000.,360.,5000.
1746.67,.473,.497,.0665,.365,,,,,SQ FT
279.7,.603,.991,,,,SQ FT
00 RECARBONATION BASIN                    770.,35200.,770.,35200.,4
0.0,0.0
4.467,.6542,.9914,1.002,,,CU FT
00 RECARBONATION-LIQUID CO2                  380.,1500.,380.,1500.
620.85,.295,.1522,.625,.129,,,,,LB/DAY
774.94,.205,.9994,,,,LB/DAY
00RECARB-CO2 FROM SUBMERGED BURNER      500.,8000.,500.,10000.,4
2270.7,.835,.1013,0.0,0.0,.607,,1.002,,LB/DAY
1969.66,.0874,.9997,1.0,,LB/DAY
00 RECARB-CO2 FROM STACK GAS                 2500.,10000.,2500.,50000.
40.71,.785,.564,.209,.124,,,,,LB/DAY
10.3008,.668,1.00161
00 MULTIPLE HEARTH RECALCINATION             179.,2930.,179.,500.,4
63685.42,.534,.072,.054,.259,.426,,1.007,,SQ FT
5445.06,.436,1.006,1.001,,,SO FT
00 CONTACT BASIN-DIRECT FILTRATION          2640.,52800.,2640.,52800.,4
0.0,0.0,0.0
9.98,.589,.999,1.001,,,CU FT
00 VACUUM DIATOMITE FILTER                    1.0,200.,1.0,50.
53269.67,.517,.361,0.0,.500,,,,,MGD
5895.49,.977,.9988,,,, MGD
00 PRESSURE DIATOMITE FILTER                  1.,5.,1.,10.
35345.6,.605,.373,.0344,.520,,,,,MGD
13406.95,.482,.994,,,, MGD
00 PRESSURE FILTRATION PLANTS             100.,1400.,100.,4000.
986.74,.611,.366,.1316,.419,,,,,SQ FT
2329.38,.3292,.9926,,,,SQ FT
00 IN-PLANT PUMPING                           1.,10.,1.,10.,3
22754.12,.696,.687,.037,.210,,,,1.01382,MGD
1274.71,.4911,.9112,, MGD
00 WASH WATER STORAGE                      21000.,900000.,21000.,900000.
0.0,0.0,0.0
.113,.848,.993,,,, GAL
00 REVERSE OSMOSIS                        1.,200.,1.,200.
602393.12,.955,.4365,.4579,,,,,, MGD
40564.,.889,.998,,,, MGD
00PRESSURE ION EXCHANGE-SOFTENING         1.0,123.,1.,4.
9021.1,.493,.089,.293,.522,,,,, MGD
```

FIGURE A-2 - CWC1.DAT (Cont'd)

```
5372.24,.989,1.005,,,, MGD
00 GRAVITY ION-EXCHANGE            2.0,150.,1.5,8.0
7892.78,.594,.068,.382,.435,,,,, MGD
5916.65,.854,.999,,,, MGD
00 PRESSURE ION EXCHANGE-NO3          1.1,12.3,1.1,12.3
33700.,.817,.047,.725,,,,,, MGD
9596.26,1.047,.9972,,,, MGD
00 ACTIVATED ALUMINA-FLOURIDE       .70,135.,70,2.0
4637.56,.191,.046,.123,.805,,,,, MGD
3491.0,1.007,1.0025,,,, MGD
00 GRAVITY GAC CONT.-CONCRETE      350.,20000.,350.,280,000.,4
101.89,.761,.282,.150,.480,,,,,CU FT
472.15,.382,1.0,1.00,,,CU FT
00 GRAVITY GAC CONTACTORS-STEEL      6280.,14100.,31400.,628000.,4
6.20,.903,.403,.112,.3936,,,,,CU FT
5.64,.8466,1.0,1.0,,,CU FT
00 PRESSURE CARBON CONTACTORS        157.,2260.,157.,6790.,4
204.84,.7809,.324,.2029,.332,,,,,CU FT
368.22,.377,1.0,,,,SQ FT
00CONVERT FILTER TO GAC CONTACTORS    370.,70000.,370.,70000.
0.,0.,0.
6.452,.9063,1.00,,,,SQ FT
00 GRAN. ACT. CARBON-CONST. COST     10000.,10000000.,10000.,10000000.
00000000000000000000000000000000000
.0543,.9611,1.0034,,,, LB
00 MAKEUP CARBON COST(O&M)            10000.,10000000.,10000.,10000000.
.513,.962,0.,1.002,,,,,,LB/YR
00000000000000000000000000000000000
00CAPPING SAND FILTER W/ANTHRACITE       350.,70000.,350.,70000.
0.,0.,0.
.383,.9818,.9994,,,,SQ FT
00REGIONAL GAC REGEN-TRAN.           1000.,20000.,30000.,3000000.
.00018,1.006,0.0,.1996,.632,,.153,,.480,CU FT
.88,1.02,1.007,,,,LB/YR
00REGIONAL MULTI HEARTH GAC REGEN       27.,1510.,27.,1510.,4
220.2,.796,,,.293,.503,,1.01,.998,SQ FT
60.02,.439,1.0056,1.002,.9995,,SQ FT
00 MULT. HEARTH GAC REGENERATION         27.,1510.,27.,1510.,4
41630.34,.809,.045,0.,.280,.589,0.,1.002,,SQ FT
6047.,.439,1.006,1.002,,,SQ FT
00 INFRARED CARBON REGEN FURNACE     2400.,60000.,2400.,4000.
800.23,.648,.494,.144,.280,,,,,LB/DAY
```

FIGURE A-2 - CWC1.DAT (Cont'd)

```
101.5,.607,.9883,,,,LB/DAY
00 FLUIDIZED BED GAC REGEN        6000.,24000.,6000.,24000.,4
964.58,.622,.0644,.188,.253,.302,,1.00,,LB/DAY
6790.79,.2282,.999,1.00,,,LB/DAY
00 POWDERED CARB REGEN-FLUIDIZED     220.,500.,220.,2000.
4233.7,.583,.370,.073,.252,.185,,,,LB/DAY
17214.,.126,.9999,,,,LB/DAY
00 POWDERED CARB REGEN-ATOMIZED      1000.,10000.,1000.,10000.
5453.1,.813,.0806,.033,.1416,.683,,,,LB/DAY
50.835,.835,.997,,,,LB/DAY
00 CHEMICAL SLUDGE PUMPING-UNTH.        20.,100.,20.,200.
1012.4,.231,.1044,.606,.222,,,,, GPM
1145.90,.0887,.9984,,,, GPM
00 CHEMICAL SLUDGE PUMPING-THICK.     50.,1250.,50.,1250.
1496.06,.553,.446,.353,.1087,,,,, GPM
267.92,.355,1.005,,,, GPM
00 GRAVITY SLUDGE THICKENER-LIME       314.,17800.,314.,1200.,4
72.10,.236,.086,.140,.734,0.,0.,1.0055,,SQ FT
142.83,.481,.984,1.004,,,SQ FT
00 GRAVITY SLUDGE THICKENER-FECL3      314.,17800.,314.,1200.,4
72.39,.235,.086,.140,.738,0.,0.,1.004,,SQ FT
142.83,.481,.984,1.004,,,SQ FT
00 VACUUM FILTER                       9.4,38.,9.4,200.
3780.42,.564,.279,.306,.331,,,,,SQ FT
5692.91,.0875,.9987,,,,SQ FT
00 BELT FILTER PRESS                   15.,30.,15.,60.
8717.06,.419,.409,.082,.438,,,,, GPM
2510.15,.5397,.9988,,,, GPM
00 FILTER PRESS                        20.,100.,4.3,20.
14469.4,.127,.144,.0288,.787,,,,,CU FT
8567.81,.200,.9969,,,,CU FT
00 DECANTER CENTRIFUGE                 10.,500.,10.,500.,4
4044.1,.483,.3246,.222,.400,0.,0.,.900,, GPM
2742.96,.387,.998,1.001,,, GPM
00 BASKET CENTRIFUGES                  3600.,36000.,3600.,36000.
6554.42,.134,.440,.153,.322,,,,,GPD
3622.26,.084,.9965,,,,GPD
00 SAND DRYING BEDS          5000.,100000.,5000.,35000.
7.69,.559,0.,.0536,.839,0.,.0955,,,SQ FT
.763,.862,1.0162,,,,SQ FT
00 SLUDGE DEWATERING LAGOONS        10000.,350000.,10000.,5000000.
.032,.926,0.,0.,.854,0.,.130,,,CU FT
.50,.648,.9917,,,,CF/YR
00 SLUDGE DISPOSAL-SANITARY SEWER        20.,10000.,20.,10000.
.22,1.00006,1.0,,,,,,, GPM
0000000000000000000000000000
00 LIQUID SLUDGE HAULING                 1.3,20.,1.25,100.,2
```

FIGURE A-2 - CWC1.DAT (Cont'd)

```
814.01,1.014,0.0,.2566,.453,0.0,.249,0.0,1.04696,MG/YR
1827.76,.460,.9877,,1.021880,,MG/YR
00 DEWATERED SLUDGE HAULING            1000.,20000.,1000.,10000.,2
2.68,.690,0.0,.2427,.469,0.0,.25028,0.0,1.046454,CY/YR
1297.15,.1026,.99677,,1.0,,MG/YR
00 RAW WATER PUMPING FACILTY          1.0,10.,1.,10.,3
23468.75,.703,.695,.037,.206,0.0,0.0,0.0,1.012651, MGD
921.6,.46477,.991,0.0,1.0027669,, MGD
00FINISHED WATER PUMPING FACILITY        1.0,10.,1.0,10.,3
30765.2,.733,.745,.0346,.169,0.0,0.0,0.0,1.00426, MGD
982.99,.4705,.993,0.0,1.002813,, MGD
00 CLEARWELL STORAGE-BELOW            10000.,50000.,10000.,50000.
000000000000000000000000000000
166.13,.263,.996,,,, GAL
00CLEARWELL STORAGE-GROUND            8500.,200000.,8500.,200000.
00000000000000000000000000000000
54.12,.341,.988,,,, GAL
00 DIFFUSED AERATION BASIN           1900.,380000.,1900.,10000.
472.32,.684,.553,.0726,.298,,,,,CU FT
15.48,.774,.993,,,,CU FT
00 AERATION-AERATION TOWERS               640.,256000.,640.,6400.
31.36,.625,.373,.286,.225,,,,,CU FT
11.59,.7199,.9965,,,,CU FT
00 ADMINISTRATION BUILD & LAB.               1.,20.,1.,10.
4813.27,.446,.1337,.103,.706,,,,, MGD
1164.4,.5707,.9926,,,, MGD
```

FIGURE A-3 CWC.DAT

```
01 CL2 FEED-CYLINDER STORAGE       1000.,10000.,300.,10000.
194.17,.6206,.270,.1226,.521,,,,,LB/DAY
125.78,.5398,.998,,,,LB/DAY
01 CL2 FEED-ON SITE STORAGE TANK     2000.,10000.,2000.,10000.
430.25,.272,0.,.370,.521,,,,,LB/DAY
90.60,.5782,1.003,,,,LB/DAY
01 CL2 FEED FROM RAIL CAR            2000.,10000.,2000.,10000.
611.58,.221,.029,.4655,.468,,,,,LB/DAY
1035.48,.262,.991,,,,LB/DAY
01 CHLORINE DIOXIDE GENERATING        500.,3.5E03,100.,3500.
347.10,.444,.076,.1798,.683,,,,,LB/DAY
239.22,.554,1.0129,,,,LB/DAY
01 OZONE GENERATION SYSTEMS              700.,3500.,100.,3500.
5664.87,.804,.776,.09,.074,,,,,LB/DAY
1324.62,.5454,1.004,,,,LB/DAY
01 OZONE CONTACT CHAMBER              46.E03,92000.,46000.,92000.
0.0,0.0,0.0
11.37,.572,.9836,,,,CU FT
01 ON-SITE HYPOCHLORITE GENERATION      750.,10000.,100.,10000.
942.87,.876,.674,.166,.085,,,,,LB/DAY
532.33,.502,1.015,,,,LB/DAY
04 ALUM FEED-LIQUID STOCK,              100.,5400.,100.,10000.
1254.53,.361,.585,0.0,.254,,,,,LB/HR
114.16,.548,.981,,,,LB/HR
04 ALUM FEED-DRY STOCK,               100.,5000.,500.,5000.
13.11,.849,.1847,.0259,.743,,,,,LB/HR
70.55,.656,.976,,,,LB/HR
01 POLYMER FEED SYSTEM,             10.,200.,1.,200.
2014.98,.0533,.294,.1037,.537,,,,.LB/DAY
801.98,.1345,.989,,,,LB/DAY
03 LIME FEED-NO RECALCINATION,        10.,10000.,100.,1000.
867.40,.2255,.087,.084,.818,,,,.LB/HR
1532.75,.188,.995,,,,LB/HR
03 LIME FEED-WITH RECALCINATION,      1000.,10000.,1000.,10000.
143.49,.466,.052,.038,.8946,,,,,LB/HR
663.60,.236,.994,,,,LB/HR
01 POTASSIUM PERMANGANATE FEED,       10.,500.,10.,500.
300.93,.178,.0789,.038,.883,,,,,LB/DAY
412.35,.139,.998,,,,LB/DAY
01 SULFURIC ACID FEED SYSTEMS,        100.,5000.,500.,5000.
4.48,.591,0.0,0.0,.926,,,,,GPD
52.2,.485,.993,,,,GPD
01 SODIUM HYDROXIDE FEED SYSTEMS,     1000.,10000.,1000.,10000.
98.09,.511,.462,.091,.362,,,,,LB/DAY
16.93,.600,.9823,,,,LB/DAY
```

FIGURE A-3 - CWC.DAT (Cont'd)

```
00 WASH WATER SURGE BASIN            100000.,500000.,10000.,500000.
0.0,0.0
308.11,.331,1.0069,,,,GAL
09 FILT. MOD-RAP SAND TO HIGH RATE        100.,28000.,100.,28000.
0.0,0.0,0.0
31.08,.656,.984,,,,SQ FT
00CONTINUOUS AUTO. BACKWASH FILTER  3000.,70400.,5000.,70400.
24.89,1.123,.728,.046,.174,,,,,SQ FT
11.06,1.005,1.017,,,,SQ FT
00 RECARBONATION BASIN                  770.,35200.,770.,35200.,4
0.0,0.0
4.467,.6542,.9914,1.002,,CU FT
00 RECARBONATION-LIQUID CO2                1500.,15000.,1500.,15000.
253.72,.518,.312,.492,.086,,,,,LB/DAY
52.42,.5677,.979,,,,LB/DAY
00RECARB-CO2 FROM SUBMERGED BURNER       8000.,10000.,500.,10000.,4
2270.7,.835,.1013,0.0,0.0,.607,,1.002,,LB/DAY
327.78,.289,.994,.999,,,LB/DAY
00 RECARB-CO2 FROM STACK GAS              10000.,50000.,2500.,50000.
40.71,.785,.564,.209,.124,,,,,LB/DAY
116.72,.401,.967,,,,LB/DAY
00 MULTIPLE HEARTH RECALCINATION            179.,2930.,500.,2930.,4
15017.0,.903,0.0,0.0,.251,.590,,1.0026,,SQ FT
5445.06,.436,1.006,1.001,,,SQ FT
09 CONTACT BASIN-DIRECT FILTRATION         2640.,52800.,2640.,52800.,4
0.0,0.0,0.0
9.98,.589,.999,1.001,,,CU FT
09 VACUUM DIATOMITE FILTER                   1.0,200.,50.,200.
278483.84,.4144,.5235,0.0,.336,,,,, MGD
5895.49,.977,.9988,,,, MGD
09 PRESSURE DIATOMITE FILTER                 5.,200.,10.,200.
132910.72,.628,.545,0.0,.298,,,,,MGD
5615.,.941,1.002,,,, MGD
09 PRESSURE FILTRATION PLANTS           1400.,28000.,4000.,28000.
1898.54,.620,.435,.141,.294,,,,,SQ FT
8.77,1.098,1.0106,,,,SQ FT
00 IN-PLANT PUMPING                          10.,200.,10.,200.,3
49859.7,.812,.821,0.0,0.0,,,,1.017,MGD
537.98,.851,.991,,, MGD
00 WASH WATER STORAGE                     21000.,900000.,21000.,900000.
0.0,0.0,0.0
.113,.848,.993,,,, GAL
14 REVERSE OSMOSIS                     1.,200.,1.,200.
602393.12,.955,.4365,.4579,,,,,,MGD
```

FIGURE A-3 - CWC.DAT (Cont'd)

```
06 FERROUS SULFATE FEED SYSTEMS,        400.,5350.,400.,5350.
9.51,.7723,0.0,0.0,.823,,,,,LB/HR
49.38,.692,.981,,,,LB/HR
05 FERRIC SULFATE FEED SYSTEMS,        400.,6600.,400.,6600.
9.82,.762,0.0,0.0,.815,,,,,LB/HR
30.67,.729,.977,,,,LB/HR
01 ANHYDROUS AMMONIA FEED FAC.,         250.,5000.,250.,5000.
401.86,.3235,.07005,.414,.461,,,,,LB/DAY
217.89,.391,1.0,,,,LB/DAY
01 AQUA AMMONIA FEED FACILITY,        250.,5000.,1000.,5000.
99.80,.148,0.0,.2635,.715,,,,,LB/DAY
63.09,.431,.999,,,,LB/DAY
16 POWDERED ACTIVATED CARBON FEED,   1000.,7000.,350.,7000.
2832.24,.552,.381,.273,.276,,,,,LB/HR
373.18,.557,.998,,,,LB/HR
07 RAPID MIX(G=60,90,    120),         1000.,20000.,1000.,20000.,1
61.81,.794,.717,0.0,.181,0.0,0.0,0.0,1.00251,CU FT
3.289,.790,.988,0.0,1.0007,,CU FT
07 RAPID MIX(G=60,90,    120),         1000.,20000.,1000.,20000.,1
61.81,.794,.717,0.0,.181,0.0,0.0,0.0,1.00251,CU FT
3.289,.790,.988,0.0,1.0007,,CU FT
07 RAPID MIX(G=60,90,    120),        1000.,20000.,1000.,20000.,1
61.81,.794,.717,0.0,.181,0.0,0.0,0.0,1.00251,CU FT
3.289,.790,.988,0.0,1.0007, ,CU FT
07 FLOCCULATION HORIZONTAL             10000.,1000000.,30000.,1000000.,1
1.553,.785,.357,.399,0.0,0.0,0.0,0.0,1.018,CU FT
5.57,.6916,.992,0.0,1.0038296,,CU FT
07 FLOCCULATION HORIZONTAL             10000.,1000000.,30000.,1000000.,1
1.553,.785,.357,.399,0.0,0.0,0.0,0.0,1.018,CU FT
5.57,.6916,.992,0.0,1.0038296,,CU FT
07 FLOCCULATION HORIZONTAL             10000.,1000000.,30000.,1000000.,1
1.553,.785,.357,.399,0.0,0.0,0.0,0.0,1.018,CU FT
5.57,.6916,.992,0.0,1.0038296,,CU FT
07 FLOCCULATION-VERTICAL                 1800.,25000.,1800.,25000.,1
21.82,.411,.148,.313,.439,0.0,0.0,0.0,1.0084, CU FT
23.63,.581,1.0086,0.0,,CU FT
07 FLOCCULATION VERTICAL               1800.,25000.,1800.,25000.,1
21.82,.411,.148,.313,.439,,,,1.0084,CU FT
23.63,.581,1.0086,,CU FT
07 FLOCCULATION VERTICAL               1800.,1000000.,1800.,1000000.,1
21.82,.411,.148,.313,.439,,,,1.0084,CU FT
23.63,.581,1.0086,,CU FT
```

FIGURE A-3 - CWC.DAT (Cont'd)

```
02 CIRCULAR CLARIFIER-LIME              1000.,31400.,1590.,31400.,4
12.60,.518,.059,.399,.506,,,1.007,,SQ FT
36.09,.701,.993,,,,SQ FT
02 CIRCULAR CLARIFIER-FECL3             1000.,31400.,1590.,31400.,4
9.25,.522,0.0,.4116,.526,,,1.006,,SQ FT
36.09,.701,.993,,,,SQ FT
02 RECTANGLE CLARIFIER-LIME             240.,4800.,600.,4800.,4
16.84,.479,0.0,.178,.746,,,1.006,,SQ FT
36.09,.701,.993,1 00047,,,SQ FT
02 RECTANGLE CLARIFIER-FECL3            240.,4800.,600.,4800.,4
17.56,.469,0.0,.181,.756,,,1.006,,SQ FT
36.09,.701,.993,1.00047,,,SQ FT
02 UPFLOW SOLIDS CONTACT CLAR           255.,14500.,2500.,14500.,5
172.64,.411,.289,.1456,.440,,0.0,1.0007,1.005,SQ FT
186.70,.5117,1.009,1.0,,SQ FT
02 UPFLOW SOLIDS CONTACT CLAR           255.,14500.,2500.,14500.,5
172.64,.411,.289,.1456,.440,,0.0,1.0007,1.005,SQ FT
186.70,.5117,1.009,1.0,,SQ FT
02 UPFLOW SOLIDS CONTACT CLAR           255.,14500.,2500.,14500.,5
172.64,.411,.289,.1456,.440,,0.0,1.0007,1.005,SQ FT
186.70,.5117,1.009,1.0,,SQ FT
00 TUBE SETTLING MODULES                280.,56000.,280.,56000.
0.0,0.0
2.9324,.9087,1.001,,,,SQ FT
09 GRAVITY FILTRATION                   5000.,28000.,1000.,28000.
249.75,.546,.147,.183,.610,,,,,SQ FT
275.62,.671,.989,,,,SQ FT
09 FILTRATION MEDIA-RAPID SAND          3500.,74800.,1000.,74800.
0.0,0.0
.7914,.9336,.9962,,,,SQ FT
09 FILTRATION MEDIA-DUAL                1400.,29900.,1000.,29900.
0.0,0.0
3.722,.8352,.991,,,,SQ FT
09 FILTRATION MEDIA-MIXED               1000.,29900.,1000.,29900.
0.0,0.0,0.0
3.677,.887,.994,,,,SQ FT
00 BACKWASH PUMPING FACILITIES          1260.,28000.,4000.,28000.
159.64,.650,.543,.219,.137,,,,,GPM
29.95,.590,.966,,,,SQ FT
00 HYDRAULIC SURFACE WASH               700.,28000.,2000.,28000.
37.51,.7146,.526,0.0,.315,,,,,SQ FT
8.64,.801,.982,,,,SQ FT
00 AIR-WATER BACKWASH FACILITIES        600.,28000.,2000.,28000.
154.89,.668,.572,.206,.129,,,,,SQ FT
193.66,.4862,.990,,,,SQ FT
```

FIGURE A-3 - CWC.DAT (Cont'd)

```
40564.,.889,.998,,,,MGD
15PRESSURE ION EXCHANGE-SOFTENING       1.0,123.,3.7,123.
12615.4,.800,.046,.619,,,,,, MGD
5372.24,.989,1.005,,,, MGD
15 GRAVITY ION-EXCHANGE             2.0,150.,8.0,150.
7163.91,.809,.079,.682,.188,,,,, MGD
5916.65,.854,.999,,,, MGD
15 PRESSURE ION EXCHANGE-NO3         1.1,12.3,1.1,12.3
33700.,.817,.047,.725,,,,,, MGD
9596.26,1.097,.9972,,,, MGD
00 ACTIVATED ALUMINA-FLOURIDE       .7,135.,2.0,135.
11257.97,.682,.1596,.526,.263,,,,, MGD
3491.0,1.007,1.0025,,,, MGD
17 GRAVITY GAC CONT.-CONCRETE       350.,20000.,350.,28000.,4
101.89,.761,.282,.150,.480,,,,,CU FT
472.15,.382,1.0,1.00,,,SQ FT
17 GRAVITY GAC CONTACTORS-STEEL      6280.,14100.,31400.,628000.,4
6.20,.903,.403,.112,.3936,,,,,CU FT
5.64,.8466,1.0,1.0,,,CU FT
17 PRESSURE CARBON CONTACTORS        157.,2260.,157.,6790.,4
204.84,.7809,.324,.2029,.332,,,,,CU FT
368.22,.377,1.0,,,,SQ FT
00CONVERT FILTER TO GAC CONTACTORS     370.,70000.,370.,70000.
0.,0.,0.
6.452,.9063,1.00,,,,SQ FT
00 GRAN. ACT. CARBON-CONST. COST      10000.,10000000.,10000.,10000000.
0000000000000000000000000000000000000
.0543,.9611,1.0034,,,,LB.
00 MAKEUP CARBON COST(O&M)          10000.,10000000.,10000.,10000000.
.513,.962,0.,1.002,,,,,,LB/YR
00000000000000000000000000000000000
09CAPPING SAND FILTER W/ANTHRACITE       350.,70000.,350.,70000.
0.,0.,0.
.383,.9818,.9994,,,,SQ FT
00REGIONAL GAC REGEN-TRAN.          1000.,20000.,30000.,3000000.
.00018,1.006,0.0,.1996,.632,,.153,,.480,CU FT
.88,1.02,1.007,,,,LB/YR
00REGIONAL MULTI HEARTH GAC REGEN      27.,1510.,27.,1510.,4
220.2,.796,,,.293,.503,,1.01,.998,SQ FT
60.02,.439,1.0056,1.002,.9995,,SQ FT
00 MULT. HEARTH GAC REGENERATION       27.,1510.,100.,1510.,4
41630.34,.809,.045,0.,.280,.589,0.,1.002,,SQ FT
6047.,.439,1.0056,1.002,,,SQ FT
00 INFRARED CARBON REGEN FURNACE     2400.,60000.,4000.,60000.
410.31,.865,.720,.069,.136,,,,,LB/DAY
101.5,.607,.9883,,,,LB/DAY
00 FLUIDIZED BED GAC REGEN         6000.,24000.,6000.,24000.,4
```

FIGURE A-3 - CWC.DAT (Cont'd)

```
964.58,.622,.0644,.188,.253,.302,,1.00,,LB/DAY
6790.,.2282,.999,1.00,,,LB/DAY
00 POWDERED CARB REGEN-FLUIDIZED     500.,33400.,2000.,33400.
5879.6,.767,.476,0.,0.,.313,,,,LB/DAY
1804.14,.4681,.9936,,,,LB/DAY
00 POWDERED CARB REGEN-ATOMIZED      1000.,10000.,1000.,10000.
5453.1,.813,.0806,.033,.1416,.683,,,,LB/DAY
50.835,.835,.997,,,,LB/DAY
00 CHEMICAL SLUDGE PUMPING-UNTH.        100.,10000.,200.,10000.
244.94,.6366,.263,.532,.128,,,,, GPM
233.24,.4351,1.001,,,, GPM
00 CHEMICAL SLUDGE PUMPING-THICK.     50.,1250.,200.,10000.
1496.06,.553,.446,.353,.1087,,,,, GPM
267.92,.355,1.005,,,, GPM
00 GRAVITY SLUDGE THICKENER-LIME       314.,17800.,1200.,17800.,4
17.06,.538,.149,.299,.493,0.,0.,1.006,,SQ FT
142.83,.481,.984,1.004,,,SQ FT
00 GRAVITY SLUDGE THICKENER-FECL3       314.,17800.,1200.,17800.,4
16.88,.508,.106,.321,.524,0.,0.,1.007,,SQ FT
142.83,.481,.984,1.004,,,SQ FT
09 VACUUM FILTER                        38.,1320.,200,1320.
7239.52,.552,.351,.279,.292,,,,,SQ FT
1202.87,.500,.989,,,,SQ FT
00 BELT FILTER PRESS                    30.,450.,30.,450.
961.258,.931,.335,.137,.396,,,,, GPM
598.69,.929,.999,,,, GPM
00 FILTER PRESS                         20.,896.,100.,896.
806.83,.625,0.,0.,.801,,,,,CU FT
3941.3,.4573,.9879,,,,CU FT
00 DECANTER CENTRIFUGE                  10.,500.,10.,500.,4
4044.1,.483,.3246,.222,.400,0.,0.,.900,, GPM
2742.96,.387,.998,1.001,,, GPM
00 BASKET CENTRIFUGES                   36000.,720000.,36000.,720000.
3.15,.968,.649,.0944,.175,,,,,GPD
3.764,.7429,.993,,,,GPD
00 SAND DRYING BEDS                100000.,400000.,35000.,400000.
.141,.955,0.,0.,.789,0.,.138,,,SQ FT
3.95,.7296,1.0093,,,,SQ FT
00 SLUDGE DEWATERING LAGOONS           350000.,5000000.,10000.,5000000.
.032,.926,0.,0.,.854,0.,.130,,,CU FT
.03207,.860,1.0064,,,,CF/YR
00 SLUDGE DISPOSAL-SANITARY SEWER        20.,10000.,20.,10000.
.22,1.00006,1.0,,,,,,, GPM
```

FIGURE A-3 - CWC.DAT (Contd.)

```
0000000000000000000000000000
00 LIQUID SLUDGE HAULING                  20.,100.,1.3,100.,2
814.01,1.014,0.0,.2566,.453,0.0,.249,0.0,1.04696,MG/YR
839.89,.730,.9878,0.0,1.03024,,MG/YR
00 DEWATERED SLUDGE HAULING            20000.,300000.,10000.,300000.,2
.117,1.02274,0.0,.266,.4705,0.0,.230,0.0,1.04621,CY/YR
6.35,.597,.982,0.0,1.031074,, MGD
00 RAW WATER PUMPING FACILTY          10.,200.,10.,200.,3
27815.70,.946,.868,0.0,.068,0.0,0.0,0.0,1.015383, MGD
305.36,.858,.999,0.0,1.00492,, MGD
00 FINISHED WATER PUMPING FACILITY        10.,300.,10.,300.,3
31646.8,.955,.887,0.0,.0583,0.0,0.0,0.0,1.004986, MGD
300.73,.903,.995,0.0,1.00263,, MGD
00 CLEARWELL STORAGE-BELOW            50000.,7500000.,50000.,7500000.
000000000000000000000000000000
.916,.7334,1.0199,,,, GAL
00 CLEARWELL STORAGE-GROUND            200000.,9400000.,200000.,9400000.
00000000000000000000000000000000
.52,.731,1.016,,,, GAL
01 DIFFUSED AERATION BASIN           1900.,380000.,10000.,380000.
112.08,.9247,.720,0.,.205,,,,,CU FT
15.48,.774,.993,,,,CU FT
01 AERATION-AERATION TOWERS         640.,256000.,6400.,256000.
6.54,.946,.654,.176,.092,,,,,CU FT
11.59,.7199,.9965,,,,CU FT
00 ADMINISTRATION BUILD & LAB             20.,200.,10.,200.
9884.6,.378,.1836,.114,.672,,,,, MGD
1674.25,.4926,1.0093,,,, MGD
```

FIGURE A-4 INDEX.DAT

```
                 THIS DATA FILE CONTAINS DEFAULT COST INFORMATION
------------------------------------------------------------------------------

          POWER COST ($/KWH)                  =.03
          LABOR COST ($/HR)                   =10.00
          PRICE INDEX                         =1.997
          NATURAL GAS                         =.0013
          DIESEL FUEL($/GAL)                  =.4500
          CONSTRUCTION COST INDEX             =2.87
          LEVEL CF CONCENTRATION              =10000.
          PERCENT OF OWNERSHIP                =90.
          INTEREST RATE                       =.08
          TOTAL DYNAMIC HEAD                  =30.
          NUMBER OF UNITS OR CONTACTORS       =1.0
          ONE WAY MILES                       =20.
          G-FACTOR                            =110.
          VARIABLE INDICATOR                  =00.
          CTSGAL.OR.DOL                       =DOL
```

VARY.DAT contains data which is used in combination with the INDEX.DAT. The way in which INDEX.DAT and VARY.DAT interact will be explained later in this Appendix. The following paragraphs discuss the purpose and proper assembly of all the above data files.

PROCES.DAT is the data file with which the user must be most familiar because it contains all of the candidate unit processes. For each unit process, the utilization range and units of measurement associated with the design and operating parameters are specified in Table A-1. The process design parameter is used to calculate the construction cost, and the operating parameter is used to determine the operation and maintenance (O&M) cost. In some cases, these parameters have different units and/or ranges. In table A-1, for example, process 42 BACKWASH PUMPING FACILITIES has the units of gpm for the design parameter and sq. ft. for its operating parameter. Plant flows are always in mgd, and all chemical dosages are in mg/l. All input values are real numbers except the process number, and are separated by commas. The card format for the PROCES.DAT data file is discussed and illustrated below.

TYPICAL FORMAT

CARD 1 - TREATMENT NUMBER, TREATMENT NAME (OPTIONAL)

CARD 2 - PLANT DESIGN SIZE, OPERATING SIZE, DESIGN PARAMETER,OPERATING PARAMETER, *CHARACTER

CARD 3 - CHEMICAL FEED RATE(mg/1), CHEMICAL COST ($/ton)

*CHARACTER VARIABLE DEPENDS ON TYPE. TREATMENT CURVE TYPES ARE LISTED IN TABLE A-1 OF THIS APPENDIX.

There are 7 types of process input formats listed in Table A-1. In order to assemble the PROCES.DAT data file, the user must follow the proper formatting structure according to the "Type". The number of cards needed for each process type along with each unit process' design and operating parameters' dimensions are given in Table A-1. The following sections contain explanations and examples of each type of process input format.

TABLE A-1. TREATMENT PROCESS TYPES

TREATMENT PROCESS - LARGE SYSTEMS No.	Process	PARAMETER RANGE	NO OF CHEMICALS	PROCESS TYPE	NO. DATA CARDS
1	CL2 Feed Cylinder Storage	10.0 to 10000.0 lb/day	1	2	3
2	CL2 Feed-On site Storage Tank	2000.0 to 10000.0 lb/day	1	2	3
3	CL2 Feed from Rail Car	2000.0 to 10000.0 lb/day	1	2	3
4	Chlorine Dioxide Generating Feed	10.0 to 3500.0 lb/day	2	2	4
5	Ozone Generation Systems	10.0 to 3500.0 lb/day	0	1	2
6	Ozone Contact Chamber	460.0 to 92000.0 cu ft	0	1	2
7	On-site Hypochlorite Generation	10.0 to 10000.0 lb/day	1	2	3
8	Alum Feed-Liquid Stock	5.4 to 5400.0 lb/hr	1	2	3
9	Alum Feed-Dry Stock	10.0 to 5000.0 lb/hr	1	2	3
10	Polymer Feed Systems	1.0 to 200.0 lb/day	1	2	3
11	Lime Feed-No Recalcination	10.0 to 1000.0 lb/hr	1	2	3
12	Lime Feed-With Recalcination	1000.0 to 10000.0 lb/hr	1	2	3
13	Potassium Permanganate Feed	1.0 to 500.0 lb/day	1	2	3
14	Sulfuric Acid Feed Systems	10.0 to 5000.0 gpd	1	2	3

TABLE A-1. TREATMENT PROCESS TYPES (Contd.)

TREATMENT PROCESS - LARGE SYSTEMS No.	Process	PARAMETER RANGE	NO OF CHEMICALS	PROCESS TYPE	NO. DATA CARDS
15	Sodium Hydroxide Feed Systems	10.0 to 10000.0 lb/day	1	2	3
16	Ferrous Sulfate Feed Systems	10.7 to 5350.0 lb/hr	1	2	3
17	Ferric Sulfate Feed Systems	13.3 to 6600.0 lb/hr	1	2	3
18	Anhydrous Ammonia Feed Facility	250.0 to 5000.0 lb/day	1	2	3
19	Aqua Ammonia Feed Facility	250.0 to 5000.0 lb/day	1	2	3
20	Powdered Activated Carbon Feed	3.5 to 7000.0 lb/hr	1	2	3
21	Rapid Mix, G=300	100.0 to 20000.0 cu ft	0	4	2
22	Rapid Mix, G=600	100.0 to 20000.0 cu ft	0	4	2
23	Rapid Mix, G=900	100.0 to 20000.0 cu ft	0	4	2
24	Flocculation-Horiz Paddle, G=20	1800.0 to 100000.0 cu ft	0	4	2
25	Flocculation-Horiz Paddle, G=50	1800.0 to 100000.0 cu ft	0	4	2
26	Flocculation-Horiz Paddle, G=80	1800.0 to 50000.0 cu ft	0	4	2
27	Flocculation-Vert Turbine, G=20	1800.0 to 2500.0 cu ft	0	4	2
28	Flocculation-Vert Turbine, G=50	1800.0 to 2500.0 cu ft	0	4	2
29	Flocculation-Vert Turbine, G=80	1800.0 to 25000.0 cu ft	0	4	2
30	Circular Clarifier-Lime Sludge	707.0 to 31400.0 sq ft	0	3	2

TABLE A-1. TREATMENT PROCESS TYPES (Contd.)

TREATMENT PROCESS - LARGE SYSTEMS No.	Process	PARAMETER RANGE	NO OF CHEMICALS	PROCESS TYPE	NO. DATA CARDS
31	Circ Clarifier-FECL3 & Alum Sldg	707.0 to 31400.0 sq ft	0	3	2
32	Rectangular Clarifier-Lime Sldg	240.0 to 4800.0 sq ft	0	3	2
33	Rect Clarifier-FECLZ3 & Alum Sldg	240.0 to 4800.0 sq ft	0	3	2
34	Upflow Solids Contact Clar. G=70	255.0 to 14500.0 sq ft	0	3	2
35	Upflow Solids Contact Clar. G=110	255.0 to 14500.0 sq ft	0	3	2
36	Upflow solids Contact Clar. G=150	255.0 to 14500.0 sq ft	0	3	2
37	Tube Settling Modules	280.0 to 56000.0 sq ft	0	1	2
38	Gravity Filtration Structure	140.0 to 28000.0 sq ft	0	1	2
39	Filtration Media-Rapid Sand	370.0 to 74800.0 sq ft	0	1	2
40	Filtration Media-Dual Media	140.0 to 29900.0 sq ft	0	1	2
41	Filtration Media-Mixed Media	140.0 to 29900.0 sq ft	0	1	2
42	Backwash Pumping Facilities O&M	1260.0 to 23000.0 gpm 1537.2 to 28060.0 sq ft	0	1	2
43	Hyraulic Surface Wash Systems	140.0 to 28000.0 sq ft	0	1	2
44	Air-Water backwash Facilities	140.0 to 28000.0 sq ft	0	1	2

TABLE A-1. TREATMENT PROCESS TYPES (Contd.)

TREATMENT PROCESS - LARGE SYSTEMS		PARAMETER RANGE	NO OF CHEMICALS	PROCESS TYPE	NO. DATA CARDS
No.	Process				
45	Wash Water Surge Basins	10000.0 to 500000.0 gal	0	1	2
46	Filter Mod-Rap Sand to High Rate	140.0 to 28000.0 sq ft	0	1	2
47	Continuous Auto. Backwash Filter	360.0 to 70400.0 sq ft	0	1	2
48	Recarbonation Basin	770.0 to 35200.0 cu ft	0	3	2
49	Recardonation-Liquid CO2 Feed	380.0 to 15000.0 lb/day	1	2	3
50	Recarb-CO2 from Submerged Burner	500.0 to 10000.0 lb/day	0	3	2
51	Recarbonation-CO2 from Stack Gas	2500.0 to 50000.0 lb/day	0	1	2
52	Multiple Hearth Recalcination	179.0 to 2930.0 sq ft	0	3	2
53	Contact Basin-Direct Filtration	2640.0 to 52800.0 cu ft	0	3	2
54	Pressure Diatomite Filter	1.0 to 200.0 mgd	3	2	5
55	Vacuum Diatomite Filters	1.0 to 200.0 mgd	3	2	5
56	Pressure Filtration Plants	140.0 to 28000.0 sq ft	0	1	2
57	In-Plant Pumping	1.0 to 200.0 mgd	0	5	2
58	Wash Water Storage Tanks	21000.0 to 900000.0 gal	0	1	2
59	Reverse Osmosis	1.0 to 200.0 mgd	3	2	5
60	Pressure Ion Exchange-Softening	1.1 to 123.0 mgd	1	2	3

TABLE A-1. TREATMENT PROCESS TYPES (Contd.)

TREATMENT PROCESS - LARGE SYSTEMS		PARAMETER RANGE	NO OF CHEMICALS	PROCESS TYPE	NO. DATA CARDS
No.	Process				
61	Gravity Ion Exchange-Softening	1.5 to 150.0 mgd	1	2	3
62	Pressure Ion Exchange-NO3 Removal	1.1 to 12.3 mgd	1	2	3
63	Activ. Alumina-Fluoride Removal	0.7 to 135.0 mgd	2	2	4
64	Gravity GAC Contactors-Concrete O&M	350.0 to 10600.0 cu ft 140.0 to 28000.0 sq ft	0	7	2
65	Gravity GAC Contactors-Steel O&M	6280.0 to 14100.0 cu ft 31400.0 to 628000.0 cu ft	0	7	2
66	Pressure Carbon Contactors O&M	390.0 to 2260.0 cu ft 157.0 to 6790.0 sq ft	0	7	2
67	Convert Filter to GAC Contactor	370.0 to 70000.0 sq ft	0	1	2
68	Granular Act Carbon-Constr Cost	10000.0 to 1000000.0 lb	0	1	2
69	Makeup Carbon Cost-O&M Only	10000.0 to 1000000.0 lb/yr	0	1	2
70	Capping Sand Filter w/Anthracite	350.0 to 70000.0 sq ft	0	1	2
71	Regional GAC Regen-Trans & Stor O&M	1000.0 to 20000.0 cu ft 30000.0 to 3000000.0 lb/yr	0	6	2
72	Regional Multi Hearth GAC Regen	27.0 to 1510.0 sq ft	0	3	2
73	Multiple Hearth GAC Regeneration	27.0 to 1510.0 sq ft	0	3	2
74	Infrared Carbon Regen Furnace	2400.0 to 60000.0 lb/day	0	1	2

TABLE A-1. TREATMENT PROCESS TYPES (Contd.)

TREATMENT PROCESS - LARGE SYSTEMS No.	Process	PARAMETER RANGE	NO OF CHEMICALS	PROCESS TYPE	NO. DATA CARDS
75	Fluidized Bed GAC Regeneration	6000.0 to 24000.0 lb/day	0	3	2
76	Powdered Carb Regen-Fluidized Bd	209.0 to 33400.0 lb/day	0	1	2
77	Powdered Carb Regen-Atomized Sus	1000.0 to 10000.0 lb/day	0	1	2
78	Chem Sludge Pumping-Unthickened	20.0 to 10000.0 gpm	0	1	2
79	Chem Sludge Pumping-Thickener-Lime	5.0 to 1250.0 gpm	0	3	2
80	Gravity Sludge Thickener-Lime	314.0 to 17800.0 sq ft	0	3	2
81	Grav Sldg Thickener-Alum & FECL3	314.0 to 17800.0 sq ft	0	1	2
82	Vacuum Filters	9.4 to 1320.0 sq ft	0	1	2
83	Belt Filter Press	15.0 to 450.0 gpm	0	1	2
84	Filter Press	4.3 to 896.0 cu ft	0	3	2
85	Decanter Centrifuges	10.0 to 500.0 gpm	0	1	2
86	Basket Centrifuges	3600.0 to 720000.0 gpd	0	1	2
87	Sand Drying Beds	5000.0 to 400000.0 sq ft	0	1	2
88	Sludge Dewatering Lagoons O&M	40000.0 to 8000000.0 cu ft 25000.0 to 5000000.0 cf/yr	0	1	2
89	Fludge Disposal-Sanitary Sewer	20.0 to 10000.0 gpm	0	6	2
90	Liquid Sludge Hauling	1.3 to 100.0 mg/yr			

TABLE A-1. TREATMENT PROCESS TYPES (Contd)

TREATMENT PROCESS - LARGE SYSTEMS		PARAMETER RANGE	NUMBER OF CHEMICALS	PROCESS TYPE	NO. DATA CARDS
No.	Process				
91	Dewatered Sludge Hauling	1000.0 to 300000.0 cy/yr	0	6	2
92	Raw Water Pumping Facility	1.0 to 200.0 mgd	0	5	2
93	Finished Water Pumping Facility	1.5 to 300.0 mgd	0	5	2
94	Clearwell Storage-Below Ground	10000.0 to 7500000.0 gal	0	1	2
95	Clearwell Storage-Ground Level	8500.0 to 9400000.0 gal	0	1	2
96	Diffused Aeration Basin	1900.0 to 380000.0 cu ft	0	1	2
97	Aeration-Aeration Towers	680.0 to 256000.0 cu ft	0	1	2
98	Admin. Lab & Maintenance Building	1.0 to 200.0 mgd	0	1	2

TYPE 1

TYPE 1 uses input cards 1 and 2 as shown below. The first card contains the treatment number and treatment name. The second card contains the plant design capacity, plant operating capacity, design feed rate, and operating feed rate. Examples are given below.

EXAMPLE 1: TREATMENT - OZONE GENERATION

Plant Design Flowrate - 12 MGD

Plant Operating Flowrate - 12 MGD

Design Parameter - 2000 lb/day

Operating Parameter - 2000 lb/day

TYPICAL CARD FORMAT

CARD 1 - TREATMENT NUMBER, TREATMENT NAME (OPTIONAL)

CARD 2 - DESIGN PLANT SIZE,OPER. PLANT SIZE, DESIGN PAR., AND OPER. PAR.

Actual input might appear as follows:

Card 1 - 4, OZONE GENERATION

Card 2 - 12.,12.,2000.,2000.

Notice that all the values above except the process number have decimal points, and are separated by commas. Card 1 contains an integer, a comma, followed by the treatment name which is optional and is used only as reference. The treatment name is optional on the first card for all the processes and is to aid the user in keeping track of what processes are in the process data file. Below is another example of a Type 1 process.

EXAMPLE 2: CARD 1 - 98, CLEARWELL STORAGE-BELOW GROUND

CARD 2 - 15.,10.,15000.,10000.

The second example above shows Process number 98 (Clearwell Storage-Below Ground). The plant design capacity is 15 MGD, the plant operating plant capacity is 10 MGD, the design parameter is 15000 GAL, and operating parameter is 10000 GAL. In both of these examples Type 1 processes there is no chemical card.

TYPE 2

Cards used for type 2 processes include Card 1, 2, and 3 as shown below. Card 3 is repeated for as many chemicals used in the process. The first card for all 7 types of input data formats is the same: Treatment Number and Treatment Name. The number and name of chemicals needed for all Type 2 processes are indicated in Table A-2 of this Appendix. The structure of a process data input using a Type 2 format is the following.

TYPICAL CARD FORMAT

CARD 1 - TREATMENT NUMBER, TREATMENT NAME

CARD 2 - DESIGN CAP., OPER. CAP., DESIGN PAR., OPER. PAR., NUMBER OF CHEMICALS

CARD 3 - CHEMICAL DOSAGE (MG/L), CHEMICAL COST ($/TON)

CARD N - CHEMICAL DOSAGE (MG/L), CHEMICAL COST ($/TON)

EXAMPLE 1

CARD 1 - 1, CL2 FEED-CYLINDER STORAGE

CARD 2 - 12., 12., 1500., 1500., 1.0

CARD 3 - 2.0, 300., CHLORINE

EXAMPLE 2

CARD 1 - 8, ALUM FEED-LIQUID STOCK

CARD 2 - 15., 10., 50., 50., 1.0

CARD 3 - 2.0, 70., (DOSE 2.0 mg/1)

EXAMPLE 3

CARD 1 - 59, REVERSE OSMOSIS

CARD 2 - 10., 7.0, 10.0, 3.0

CARD 3 - 20., 250.2, SULFURIC ACID

CARD 4 - 5.0, 62.6, SODIUM HEXAMETAPHOSPHATE

CARD 5 - 2., 250., CHLORINE

TABLE A-2 CHEMICALS FOR TREATMENT PROCESSES

TREATMENT PROCESS - LARGE SYSTEMS		CHEMICAL USED
1	Cl_2 Feed-Cylinder Storage	Chlorine
2	Cl_2 Feed On-Site Storage Tank	Chlorine
3	Cl_2 Feed from Rail Car	Chlorine
4	Chlorien Dioxide Generating, Feed	Chlorine, Salt
7	On-Site Hypochlorite Generation	Salt
8	Alum Feed - Liquid Stock	Alum-Liquid Stock
9	Alum Feed - Dry Stock	Alum-Dry Stock
10	Polymer Feed Systems	Polymer
11	Lime Feed - No Recalcination	Lime
12	Lime Feed - With Recalcination	Lime
13	Potassium Permanganate Feed	Potassium Permanganate
14	Sulfuric Acid Feed Systems	Sulfuric Acid
15	Sodium Hydroxide Feed Systems	Sodium Hydroxide
16	Ferrous Sulfate Feed Systems	Ferrous Sulfate
17	Ferric Sulfate Feed Systems	Ferric Sulfate
18	Anhydrous Ammonia Feed Facility	Anhydrous Ammonia
19	Aqua Ammonia Feed Facility	Aquaceous Ammonia
20	Powdered Activated Carbon Feed	Powdered Activated Carbon
49	Recarbonation-Liquid CO_2 Feed	Liquid Carbon Dioxide
54	Pressure Diatomite Filters	Polymer, Alum, Diatomaceous Earth
55	Vacuum Diatomite Filter	Polymer, Alum, Diatomaceous Earth
59	Reverse Osmosis	Sulfuric Acid, Hexametaphosphate, Chlorine
60	Pressure Ion Exchange-Softening	Salt
61	Gravity Ion Exchange-Softening	Salt
61	Pressure Ion Exchange - NO_3 Removal	Salt
63	Activ. Alumina - Fluoride Removal	Sodium Hydroxide, Sulfuric Acid

Example 1 shows process 1, CL2-FEED CYLINDER STORAGE assuming the design plant capacity and operating plant capacity is 12 MGD. The design and operating parameters are 1500 lb/day; respectively. Notice, since there's only one chemical, used in this treatment process the number 1.0 follows the operating parameter. The last card of the first example contains the chemical dosage in mg/l and chemical cost in $/ton separated by commas.

Example 2 is essentially the same as example 1 except that a different process is being illustrated. Example 3 shows a process, Reverse Osmosis that uses three chemicals: Sulfuric Acid, Sodium Hexametaphosphate, and Chlorine. Since there are three chemicals used in the process, the number 3.0 follows the operating parameter, and the last three cards contain information on chemical dosage and chemical cost. Table A-2 contains chemicals for treatment processes.

TYPE 3

The Type 3 process format uses two cards to complete a data run. The first card is structured the same as previous types. The second card's format is as follows: DESIGN PLANT CAPACITY, OPERATING PLANT CAPACITY, DESIGN PLANT PARAMETER, OPERATING PLANT CAPACITY, NUMBER OF UNITS OR CONTACTORS.

TYPICAL CARD FORMAT

CARD 1 - TREATMENT NUMBER, TREATMENT NAME

CARD 2 - DESIGN PLANT CAPACITY, OPER. PLANT CAPACITY, DESIGN PARAMETER, OPERATING PARAMETER, NUMBER OF UNITS OR CONTACTORS

EXAMPLE 1

CARD 1 - 30, CIRCULAR CLARIFIER - LIME SLUDGE

CARD 2 - 20.,20.,21000.,21000.,2.0

EXAMPLE 2

CARD 1 - 31, CIRCULAR CLARIFIER - FECL3 & ALUM SLUDGE

CARD 2 - 20.,20.,21000.,21000.,1.0

Example 1 shows process 30, CIRCULAR CLARIFIER-LIME. Its design and operating capacities are 20 MGD. The design and operating parameters are 21000 sq ft. The number of units or clarifiers (2) is entered onto the second card after the operating parameter.

In the second example there is only one clarifier used since 1.0 is entered after the 21000. sq ft. operating parameter.

TYPE 4

Type 4 processes use 2 cards for input. The first card is the same as the previous types of data input format: TREATMENT NUMBER, TREATMENT NAME. The second card contains; DESIGN CAPACITY, OPERATING PLANT CAPACITY, DESIGN PARAMETER, OPERATING PARAMTETER and G-FACTOR. Table A-3 indicates the range of the G-FACTOR for TYPE 4 processes.

The following examples are provided.

TYPICAL CARD FORMAT

CARD 1 - TREATMENT NUMBER, TREATMENT NAME

CARD 2 - DESIGN PLANT CAPACITY, OPERATING PLANT CAPACITY, DESIGN PARAMETER, G-FACTOR

EXAMPLE 1

```
21, RAPID MIX

12.,12.,2000.,2000.,300.
```

EXAMPLE 2

```
26, FLOCCULATION-HORIZ.

12.,12.,3000.,3000.,20.
```

Example 1 contains input to estimate cost for 21, Rapid Mix. The design and operating capacities are both 12 MGD. The design and operating parameters are both 2000 cu ft. with a G-Factor of 300.

TABLE A-3. SPECIAL FACTORS

NUMBER	PROCESS	TDH, MILES, & G FACTOR RANGES
21, 22, 23	Rapid Mix	G-Factor (300-900)
24-29	Flocculation	G-Factor (20-80)
34-36	Upflow Solids Contact	G-Factor (70-150)
90	Liquid sludge Hauling	One Way Miles (5-40)
91	Dewater Sludge Hauling	One Way Miles (5-40)
92	Raw Water Pumping Fac.	Total Dyn. Head (30-100 ft)
93	Finished Water Pumping FAC.	Total Dyn. Head (100-300 ft)

Example 2 similarly utilizes a type 4 input format but the G-Factor now is 20 instead of 300 as was in the previous example. The G-FACTOR range is given in Table A-2.

TYPE 5

Type 5 data input format is similar to that for type 4 except that the Total Dynamic Head is substituted in place of the G Factor value.

EXAMPLE 1

57, IN PLANT PUMPING

10.,10.,10.,10.,30.,FT.

In the above example, cost is to be determined for a IN-PLANT PUMPING process that has a design capcacity, operating capacity, design parameter, and operating parameter all of 10 MGD. Its total dynamic head value is 30 feet. The range of the total dynamic head is shown in Table A-3.

TYPE 6

Type 6 processes use two card inputs with the following format:

TYPICAL CARD FORMAT

CARD 1 - TREATMENT NUMBER, TREATMENT NAME

CARD 2 - DESIGN CAPACITY,OPERATING CAPACTY,DESIGN PARAMETER,
OPERATING PARAMETER,ONE WAY MILES

EXAMPLE 1

90, DEWATERED SLUDGE HAULING

12.,12.,2000.,2000.,20.

The above example illustrates the following: 12 MGD DESIGN PLANT SIZE, 12 MGD OPERATING PLANT SIZE, 2000 CY/YR DESIGN AND OPERATING PARAMETERS, and 20 MILES ONE WAY DISTANCE. Table A-3 gives the range in miles in one direction either going to or leaving from the plant for all Type 6 processes.

SENSITIVITY ANALYSIS

In order to become familiar with the sensitivity analysis feature of the cost estimating program, the user must first refer to Figure A-4 of the appendix showing INDEX.DAT. The purpose of the data file is to store information on all the initial or assumed cost information and all the necessary economic inidices that are used to measure the effect of inflation on cost.

When making changes to this file, it is important that the user keeps all the "=" signs lined-up and all the data left justified with respect to "=" signs to assure that the program is interpretting the data correctly.

The last line in the INDEX.DAT data file contains VARIABLE INDICATOR. By entering one of the coded numbers listed in Figure A-5, the user may vary some of the given values that are normally held fixed in the INDEX.DAT data file. The VARY.DAT file holds that data the user wishes to use in place of the initially fixed value.

For example if the user wanted to investigate the sensitivity that changes in power cost would have on a given treatment process, entering the real number 1.0 into the VARIABLE INDICATOR position in the index.dat data file will tell the program that power cost is no longer to be held fixed at .03 and to get the new values out of the VARY.DAT as the one listed in Figure A-6. Using the data file in Figure A-6, the new power cost values will be .04,.05,.06, and .08. Similarly, sensitivity analysis can be made on all the variables listed in Figure A-5. Several examples are show on the following page to aid the user in utilizing the sensitivity analysis feature of this computer program.

Below are examples of how to run sensitivity analysis on the Construction Cost Index (CCI), and Wholesale Price Index(WPI). This feature can be used with any combination of treatment processes stored in PROCESS.DAT for cost estimating.

In order to vary the Construction Cost Index from 1.00 to 4.00 in one step increments, the user has to assemble INDEX.DAT and VARY.DAT in the following manner. The user must refer to Figure A-5 to attain the variable indicator code. In the case of Example 1, shows below the code number is 6.0. The numbers listed in VARY.DAT are used for the Construction Cost Index instead of the one held fixed in the INDEX.DAT.

FIGURE A-5

VARIABLE NAME	VARIABLE INDICATOR CODE
NULL	0.0
POWER ($/kwh)	1.0
DHR ($/hr)	2.0
WPI	3.0
NTGAS	4.0
DIESL	5.0
CCI	6.0
CONCENTRATION LEVEL	7.0
PERCENT OF OWNERSHIP	8.0
INTEREST RATE	9.0

FIGURE A-6

The data format for the VARY.DAT is FREE FORMATTED.

VARY.DAT

```
.04
.05
.06
.07
.08
```

EXAMPLE 2

INDEX.DAT (SEE FIGURE A-4)

```
POWER COST($/kwh)                              =.03
       "                                        "
       "                                        "
       "                                        "
       "                                        "


VARIABLE INDICATOR                             =3.0
```

VARY.DAT

```
1.40
1.80
2.00
```

In this data run the Wholesale Price Index will be changed from 1.40, to 1.80 to 2.00 for sensitivity purposes also. If a data run without sensitivity analysis is desired, entering 0.0 in as the Variable Indicator is necessary.

EXAMPLES OF USING PROGRAM FOR GROUPS OF UNIT PROCESSES

The three examples of PROCES.DAT shown in Figure A-7 illustrates how a string of unit processes can be assembled for estimating cost for an entire water treatment plant. Figure A-8 shows the printout after executing the program using each of the corresponding PROCES.DAT files shown in Figure A-7. The INDEX.DAT files used for each data run are in Figure A-9.

In the first two examples, the cost are in terms of cents per thousand gallons and in the third example the cost is in terms of dollars per year. Units of cost can be chosen by an entry in the Index.Dat file; namely, the last entry in Index.Dat and appears as the following:

```
POWER COST($/KWH)                 =.03
       "                          = "
       "                          = "
       "                          = "
       "                          = "
CTSGAL.OR.DOL.                    = CTSGAL
```

Entering CTSGAL into the last entry allows the program to estimate cost in terms of cents per thousand gallons, and entering DOLLARS alters the cost into terms of dollars per year.

FIGURE A-7 PROCES.DAT FOR THREE EXAMPLES

PROCES.DAT

EXAMPLE 1

```
59,REVERSE OSMOSIS
5.,3.5,5.,3.5,3.0
35.67,65.,SULFURIC ACID
7.13,650.,SODIUM HEXA
1.,300.,CHLORINE
94,CLEARWELL STORAGE - BELOW GROUND
5.,3.5,300000.,300000.
1,CL2 FEED- CYLINDER STORAGE
5.,3.5,63.,44.,1.0
1.5,300.,CHLORINE
93, FINISHED WATER PUMPING FACILITY
5.,3.5,8.,3.5,200.
```

EXAMPLE 2

```
57,IN-PLANT PUMPING
5.0,3.5,5.,3.5,75.0
60,PRESSURE ION EXCHANGE-SOFTENING
5.,3.5,5.,3.5,1.0
2.,30.60,SALT
15,SODIUM HYDROXIDE FEED SYSTEMS
5.,3.5,625.,438.,1.0
15.,200.,SODIUM HYDROXIDE
1,CL2 FEED-CYLINDER STORAGE
5.,3.5,63.,44.,1.0
1.5,300.,CHLORINE
95,CLEARWELL STORAGE - GROUND LEVEL
5.,3.5,500000.,500000.
93,FINISHED WATER PUMPING FACILITY
5.,3.5,8.,3.5,200.
```

EXAMPLE 3

```
11,LIME FEED-NO RECALCINATION
1.,.70,8.7,6.1,1.0
25.,65.,LIME
```

```
                                        EXAMPLE 1

                                        COST SUMMARY FOR WATER TREATMENT PROCESSES

              PROCESS                 FLOW-MGD            PROCESS PARAMETER          COSTS-DOLLARS          COSTS-CTS/1000 GAL
                                   DESIGN   ACTUAL       DESIGN      OPERATING      CONSTR     CAPITAL     O&M    DEBT   TOTAL

 1  REVERSE OSMOSIS                 5.000   3.500       5.0 MGD        3.5 MGD     3577520.   4770027.  49.363  35.245  84.608

       65.00$/TON OF SULFURIC ACID
   FEED RATE                  =  190.TONS/YR.
   CHEMICAL DOSAGE            =    35.67 MG/L

       650.00$/TON OF SODIUM HEXA
   FEED RATE                  =   38.TONS/YR.
   CHEMICAL DOSAGE            =     7.13 MG/L

       300.00$/TON OF CHLORINE
   FEED RATE                  =    5.TONS/YR.
   CHEMICAL DOSAGE            =     1.00 MG/L
 2  CLEARWELL STORAGE-BELOW         5.000   3.500   300000.0       300000.0  GAL     205542.    274056.   0.000   2.025   2.025
 3  CL2 FEED-CYLINDER STORAGE       5.000   3.500      63.0 LB/DAY     44.0 LB/DAY    25488.     33984.   0.813   0.251   1.065

       300.00$/TON OF CHLORINE
   FEED RATE                  =    8.TONS/YR.
   CHEMICAL DOSAGE            =     1.50 MG/L
 4 FINISHED WATER PUMPING FACILITY  5.000   3.500       8.0  MGD       3.5  MGD      96208.    128277.   1.565   0.948   2.513
   TOTAL DYNAMIC HEAD = 200.0
                                                                            ________________________________________________

                                                                     TOTAL  3904758.   5206344.  51.742  38.469  90.211


                                              UNIT COST FACTORS

                                      ELECTRICITY, $/KWH            =  0.03
                                      LABOR, $/HR                   = 10.00
                                      DIESELFUEL, $/GAL             = 0.450
                                      NATURAL GAS, $/CU FT          =0.0013
                                      PRODUCER PRICE INDEX          =   2.00
                                      CONST. COST INDEX             =  2.87
                                      AMORTIZATION PERIOD,          = 20.00
                                      INTEREST  RATE(%)             =  0.07
```

FIGURE A-8 EXAMPLE 1 COST SUMMARY

```
                                              EXAMPLE 2

                                 COST SUMMARY FOR WATER TREATMENT PROCESSES

          PROCESS                  FLOW-MGD            PROCESS PARAMETER           COSTS-DOLLARS       COSTS-CTS/1000 GAL
                                DESIGN   ACTUAL      DESIGN        OPERATING      CONSTR     CAPITAL    O&M    DEBT   TOTAL

1  IN-PLANT PUMPING              5.000   3.500      5.0 MGD        3.5  MGD      54074.      72099.   1.784   0.533   2.316
  TOTAL DYNAMIC HEAD =  75.0
2 PRESSURE ION EXCHANGE-SOFTENING 5.000  3.500      5.0  MGD       3.5  MGD     560659.     747546.   3.930   5.524   9.454

    30.60$/TON OF SALT
  FEED RATE               =   11.TONS/YR.
  CHEMICAL DOSAGE         =     2.00 MG/L
3  SODIUM HYDROXIDE FEED SYSTEMS.  5.000  3.500   625.0 LB/DAY    438.0 LB/DAY    23998.      31997.   1.380   0.236   1.616

   200.00$/TON OF SODIUM HYDROXIDE
  FEED RATE               =   80.TONS/YR.
  CHEMICAL DOSAGE         =    15.00 MG/L
4  CL2 FEED-CYLINDER STORAGE       5.000  3.500    63.0 LB/DAY     44.0 LB/DAY    25488.      33984.   0.813   0.251   1.065

   300.00$/TON OF CHLORINE
  FEED RATE               =    8.TONS/YR.
  CHEMICAL DOSAGE         =     1.50 MG/L
5  CLEARWELL STORAGE-GROUND        5.000  3.500  500000.0        500000.0  GAL   163776.     218368.   0.000   1.613   1.613
6 FINISHED WATER PUMPING FACILITY  5.000  3.500       8.0  MGD       3.5  MGD     96208.     128277.   1.565   0.948   2.513
  TOTAL DYNAMIC HEAD = 200.0
                                                                            ------------------------------------------------
                                                                    TOTAL   924203.    1232271.   9.473   9.105  18.578


                                          UNIT COST FACTORS

                                ELECTRICITY, $/KWH           =  0.03
                                LABOR, $/HR                  = 10.00
                                DIESELFUEL, $/GAL            = 0.450
                                NATURAL GAS, $/CU FT         =0.0013
                                PRODUCER PRICE INDEX         =   2.00
                                CONST. COST INDEX            =  2.87
                                AMORTIZATION PERIOD,         = 20.00
                                INTEREST  RATE(%)            =  0.07
```

FIGURE A-8 (CONT)   EXAMPLE 2   COST SUMMARY

```
                                   EXAMPLE 3


                                      COST SUMMARY FOR WATER TREATMENT PROCESSES

                                                          PROCESS PARAMETER              COSTS-DOLLARS       COSTS-THOUS. DOL/YR
            PROCESS                     FLOW-MGD        DESIGN       OPERATING         CONSTR     CAPITAL     O&M    DEBT   TOTAL
                                      DESIGN  ACTUAL
 1  LIME FEED-NO RECALCINATION,        1.000  0.700     8.7 LB/HR      6.1 LB/HR       48393.     64524.      7.7     6.1    13.8

     65.00$/TON OF LIME
   FEED RATE                  =   27.TONS/YR.
   COST FOR LIME              =  1733.4 $/YEAR
   CHEMICAL DOSAGE            =    25.00 MG/L
OPERATING OR CAPITAL PARAMETER OUTSIDE OF EQUATIONRANGE> LIME FEED-NO RECALCINATION,

 RANGE FOR O&M EQUATION IS          10.0  TO         100.0
 RANGE FOR CAPITAL EQUATION IS=          10.0  TO          1000.0
                                                                              ___________________________________________________
                                                                        TOTAL  48393.     64524.    7.726   6.091  13.817


                                          UNIT COST FACTORS

                                      ELECTRICITY, $/KWH                  =  0.03
                                      LABOR, $/HR                         = 10.00
                                      DIESELFUEL, $/GAL                   = 0.450
                                      NATURAL GAS, $/CU FT                =0.0013
                                      PRODUCER PRICE INDEX                =   2.00
                                      CONST. COST INDEX                   =  2.87
                                      AMORTIZATION PERIOD,                = 20.00
                                      INTEREST  RATE(%)                   =  0.07
```

FIGURE A-8 (CONT) EXAMPLE 3 COST SUMMARY

FIGURE A-9 INDEX.DAT FILE FOR EXAMPLES

BELOW IS THE INDEX.DAT FILE UTILIZED BY THE FIRST TWO EXAMPLES

```
  INDEX.DAT


THIS    DATA   FILE    CONTAINS  FIXED COST INFORMATION
---------------------------------------------------------------------------------
          POWER   COST($/KWH)                =.03
          LABOR  COST($/HR)                  =10.00
     WHOLESALE PRICE INDEX                   =1.997
         NATURAL  GAS                        =.0013
           DIESEL FUEL($/GAL)                =.4500
    CONSTUCTION COST INDEX                   =2.87
     LEVEL OF CONCENTRATION                  =10000.
     PERCENT OF OWNERSHIP                    =90.
        INTEREST RATE                        =.07
      TOTAL DYNAMIC HEAD                     =30.
       NUMBER OF UNITS OR CONTACTORS         =1.0
       ONE WAY MILES                         =20.
       G-FACTOR                              =150.
       VARIABLE INDICATOR                    =00.
       CTSGAL.OR.DOL/YR.                     =CTSGAL
```

BELOW IS THE INDEX.DAT FILE USED BY THE THIRD EXAMPLE

```
          INDEX.DAT
THIS      DATA   FILE    CONTAINS  FIXED COST INFORMATION
---------------------------------------------------------------------------------
          POWER   COST($/KWH)                =.03
          LABOR  COST($/HR)                  =10.00
     WHOLESALE PRICE INDEX                   =1.997
         NATURAL  GAS                        =.0013
           DIESEL FUEL($/GAL)                =.4500
    CONSTUCTION COST INDEX                   =2.87
     LEVEL OF CONCENTRATION                  =10000.
     PERCENT OF OWNERSHIP                    =90.
        INTEREST RATE                        =.07
      TOTAL DYNAMIC HEAD                     =30.
       NUMBER OF UNITS OR CONTACTORS         =1.0
       ONE WAY MILES                         =20.
       G-FACTOR                              =150.
       VARIABLE INDICATOR                    =00.
       CTSGAL.OR.DOL/YR.                     =DOL.
```

APPENDIX B - COMPUTER USER'S GUIDE FOR QUANTITY EQUATIONS

In addition to the cost equation program, a cost/quantity equation has been developed based on the data in Table 9. To set these data it is necessary to make the following entry into the INDEX.DAT data file.

BELOW IS PARTIAL ILLUSTRATION OF INDEX.DAT

```
POWER COST($/KWH)                    =.03

LABOR COST($/YR)                     =10.00

                                        "
   "
                                        "
   "
DETAIL.OR.SUMMARY                    =DETAIL
```

The entry DETAIL tells the computer program to print out a itemized listing of construction and operations costs. When a detailed listing is printed, the following information is also given: a listing of all operating and capital expenditures summarized by process, a table of O&M costs itemized in terms of electrical energy(KWH/YR), LABOR(HR/YR), MAINTENANCE MATERIAL($/YR), DIESEL FUEL(GAL/YR), NATURAL GAS(SCF/YR), and CHEMCAL COST($/YR).

When a detailed listing is specified, the operating and maintenance costs are based on the quantity equations shown in Table 9 instead of the cost equations. For example, if an operating and maintenance cost estimate is desired for a 10 MGD CLORINE FEED CYLINDER STORAGE unit process based on a 2000 lb/day operating feedrate, the cost estimating procedure would be as the following.

1. $1.25\ \mathrm{USRT}^{1.1105} = 5790.34$ kwh/yr PROCESS ENERGY

   $441.89\ \mathrm{USRT}^{.305} = 4488.7$ dol/yr MAINTENANCE MATERIAL

   $1.596\ \mathrm{USRT}^{.626} = 185.98$ hr/yr LABOR

   $490.95\ \mathrm{USRT}^{.781} = 185841.1$kwh/yr BLDEN-ENERGY

2. 5790 X .03$/kwh = 173.7 $/yr PROCESS ENERGY YEARLY COST

4488.7 X 1.00 = 4488.7 $/yr MAINTENANCE MATERIAL YEARLY COST

185.98 X 10.00$/hr = 1859.8 $/yr LABOR YEARLY COST

185841.1 X .03$/kwh = 5575.23 $/yr BLDEN-ENERGY YEARLY COST

3. TOTAL O&M COST = 173.7 + 4488.7 + 1859.8 + 5575.23

= 12097.43$/yr (does not include chemical cost)

If two program executions are made for the same size unit process, first using a summary formatted output and then a detailed listing; the O&M cost in each respective execution may show slight differences. This is because of costs based on two different cost estimating approaches. One is based on the cost estimations equations in Tables 4 through 7 except for chemical costs. The other involves quantities. Both were estimated independently.

Below the O&M itemization table is another table that breaks down the construction costs into the following areas based on the construction cost distribution factors shown in Table 8: EXCAVATION, MANUFACTURED EQUIPMENT, CONCRETE, STEEL, LABOR, PIPE & VALVES, ELECTRICAL & INSTRUMENTATION, and HOUSING.

<u>BELOW IS PARTIAL ILLUSTRATION OF INDEX.DAT</u>

```
POWER COST($/KWH)            =.03

LABOR COST($/KWH)            =10.00

   ..                          ..

   ..                          ..

DETAIL.OR.SUMMARY            =SUMMARY
```

The entry SUMMARY informs the computer to print a brief summary listing as shown in FIGURE B-1. This listing gives the user total O&M and unitized Capital cost information.

After a user specifies DETAIL in the INDEX.DAT data file, the construction cost itemization table scenario would implement the construction cost factors in the following way for the unit process, CL2 FEED-CYLINDER STORAGE.

```
                                              EXAMPLE 2

                                COST SUMMARY FOR WATER TREATMENT PROCESSES

                                                           PROCESS PARAMETER              COSTS-DOLLARS       COSTS-CTS/1000 GAL
          PROCESS                      FLOW-MGD                                                              O&M    DEBT   TOTAL
                                    DESIGN   ACTUAL      DESIGN        OPERATING      CONSTR      CAPITAL

1  IN-PLANT PUMPING                  5.000    3.500      5.0 MGD        3.5  MGD       54074.      72099.   1.784  0.533   2.316
  TOTAL DYNAMIC HEAD =  75.0
2 PRESSURE ION EXCHANGE-SOFTENING    5.000    3.500      5.0  MGD       3.5  MGD      560659.     747546.   3.930  5.524   9.454

    30.60$/TON OF SALT
  FEED RATE                  =   11.TONS/YR.
  CHEMICAL DOSAGE            =     2.00 MG/L
3  SODIUM HYDROXIDE FEED SYSTEMS,    5.000    3.500    625.0 LB/DAY   438.0 LB/DAY     23998.      31997.   1.380  0.236   1.616

    200.00$/TON OF SODIUM HYDROXIDE
  FEED RATE                  =   80.TONS/YR.
  CHEMICAL DOSAGE            =    15.00 MG/L
4  CL2 FEED-CYLINDER STORAGE         5.000    3.500     63.0 LB/DAY    44.0 LB/DAY     25488.      33984.   0.813  0.251   1.065

    300.00$/TON OF CHLORINE
  FEED RATE                  =    8.TONS/YR.
  CHEMICAL DOSAGE            =     1.50 MG/L
5  CLEARWELL STORAGE-GROUND          5.000    3.500  500000.0         500000.0  GAL   163776.     218368.   0.000  1.613   1.613
6 FINISHED WATER PUMPING FACILITY    5.000    3.500      8.0  MGD       3.5  MGD       96208.     128277.   1.565  0.948   2.513
  TOTAL DYNAMIC HEAD = 200.0
                                                                    ------------------------------------------------------------
                                                                    TOTAL     924203.    1232271.   9.473  9.105  18.578


                                          UNIT COST FACTORS

                                 ELECTRICITY, $/KWH            =  0.03
                                 LABOR, $/HR                   = 10.00
                                 DIESELFUEL, $/GAL             = 0.450
                                 NATURAL GAS, $/CU FT          =0.0013
                                 PRODUCER PRICE INDEX          =   2.00
                                 CONST. COST INDEX             =  2.87
                                 AMORTIZATION PERIOD,          = 20.00
                                 INTEREST  RATE(%)             =  0.07
```

FIGURE B-1 SUMMARY OF COST DATA

EXCAVATION = CONSTRUCTION COST X .00

MANUFACTURED
EQUIPMENT = CONSTRUCTION COST X .50

CONCRETE = CONSTRUCTION COST X .00

STEEL = CONSTRUCTION COST X .00

LABOR = CONSTRUCTION COST X .06

PIPE &
VALVES = CONSTRUCTION COST X .04

ELECTRICAL &
INSTRUMENTATION = CONSTRUCTION COST X .06

HOUSING = CONSTRUCTION COST X .34

Note that the construction cost is in terms of total dollars.

Examples of a program execution using the detailed format is shown in Figure B-2. Figure B-3 illustrates the INDEX.DAT data files utilized by the program in executing the outputs in Figures B-1 and B-2.

FIGURE B-2 DETAILED COST SUMMARY FOR WATER TREATMENT UNIT PROCESSES

```
                                    COST SUMMARY FOR WATER TREATMENT PROCESSES

          PROCESS                 FLOW-MGD            PROCESS PARAMETER           COSTS-DOLLARS        COSTS-CTS/1000 GAL
                               DESIGN   ACTUAL       DESIGN       OPERATING      CONSTR     CAPITAL    O&M    DEBT   TOTAL
1 PRESSURE ION EXCHANGE-SOFTENING  5.000    3.500       5.0  MGD        3.5  MGD   560659.    747546.  2.995  5.524  8.519

    30.60$/TON OF SALT
  FEED RATE              =     5.TONS/YR.
  CHEMICAL DOSAGE        =     1.00 MG/L
2  SODIUM HYDROXIDE FEED SYSTEMS,  5.000   3.500    625.0 LB/DAY    438.0 LB/DAY   23998.     31997.  1.371  0.236  1.607

   200.00$/TON OF SODIUM HYDROXIDE
  FEED RATE              =   80.TONS/YR.
  CHEMICAL DOSAGE        =    15.00 MG/L
3  CL2 FEED-CYLINDER STORAGE       5.000   3.500     63.0 LB/DAY     44.0 LB/DAY   25488.     33984.  0.453  0.251  0.705

   300.00$/TON OF CHLORINE
  FEED RATE              =    8.TONS/YR.
  CHEMICAL DOSAGE        =     1.50 MG/L
4  CLEARWELL STORAGE-GROUND        5.000   3.500  500000.0         500000.0  GAL  163776.    218368.  0.000  1.613  1.613
5 FINISHED WATER PUMPING FACILITY  5.000   3.500       8.0  MGD         3.5  MGD   96208.    128277.  1.128  0.948  2.076
  TOTAL DYNAMIC HEAD = 200.0
6  IN-PLANT PUMPING
                                   5.000   3.500      5.0 MGD          3.5  MGD    54074.     72099.  1.352  0.533  1.884
  TOTAL DYNAMIC HEAD =  75.0
                                                                             ----------------------------------------------
                                                                    TOTAL  924203.   1232270.  7.299  9.105 16.404


                              OPERATING  AND  MAINTENANCE BREAKDOWN SUMMARY

   PROCESS                 MAINTENANCE        LABOR         BUILDING          DIESEL               NATURAL   CHEMICALS
   ENERGY                  MATERIAL                         ENERGY            FUEL                   GAS
   (KWH/YR)                ($/YR)            (HR/YR)        (KWH/YR)          (GAL/YR)             (SCF/YR)    ($/YR)
1      7198.                 15392.           1866.          127655.             0.                     0.       163.
2      3320.                   122.            107.            7326.             0.                     0.     16001.
3        84.                  1401.            171.            9431.             0.                     0.      2400.
4         0.                     0.              0.               0.             0.                     0.         0.
5    381832.                   632.            232.               0.             0.                     0.         0.
6    452667.                   624.            306.               0.             0.                     0.         0.



                              CONSTRUCTION  COST  ITEMIZATION  IN TOTAL DOLLARS

     EXCAVATION         MANUFACTURED   CONCRETE      STEEL         LABOR        PIPE &         ELECTRICAL &     HOUSING
                         EQUIPMENT                                              VALVES         INSTRUMENTATION
1       5607.             291543.        5607.        5607.         5607.        89705.         89705.           67279.
2         0.                9359.          0.           0.          1200.         1200.          4320.            7919.
3         0.               12744.          0.           0.          1529.         1020.          1529.            8666.
4         0.              116281.      13102.        9827.          1638.        14740.          8189.               0.
5         0.               39445.          0.           0.         10583.        21166.         25014.               0.
6       541.               11896.       1081.        1622.         15141.        14600.          5948.            3244.

                                          UNIT COST FACTORS

                               ELECTRICITY, $/KWH                  =  0.03
                               LABOR, $/HR                         = 10.00
                               DIESELFUEL, $/GAL                   = 0.450
                               NATURAL GAS, $/CU FT                =0.0013
                               WHOLESALE PRICE INDEX               =   2.00
                               CONST. COST INDEX                   =  2.87
                               AMORTIZATION PERIOD,                = 20.00
                               INTEREST  RATE(%)                   =  0.07
```

Below is the data file used to retrieve cost using a detailed printout.

```
              THIS DATA FILE CONTAINS FIXED COST INFORMATION
-----------------------------------------------------------------------


     POWER COST ($/KWH)                     = 0.3
     LABOR COST ($/HR)                      = 10.00
     WHOLESALE PRICE INDEX                  = 1.997
     NATURAL GAS (SFC)                      = 0.013
     DIESEL FUEL ($/GAL)                    = .4500
     CONSTRUCTION COST INDEX                = 2.87
     LEVEL OF CONCENTRATION                 = 10000.
     PERCENT OWNERSHIP                      = 90
     INTEREST RATE                          = .07
     TOTAL DYNAMIC HEAD (FT)                = .30
     NUMBER OF UNITS OR CONTACTORS          = 1.0
     ONE WAY MILES                          = 20.
     G-FACTOR                               = 150.
     VARIABLE INDICATOR                     = 00.
     WHICH UNIT (CTSGAL.OR.DOLYR)           = CTSGAL
     DETAIL OR SUMMARY OUTPUT               = DETAIL
```

Below is the data file that enables the program to utilize the summarized printout.

```
-----------------------------------------------------------------------


     POWER COST ($/KWH)                     = .03
     LABOR COST ($/HR)                      = 10.00
     WHOLESALE PRICE INDEX                  = 1.997
     NATURAL GAS (SCF)                      = .0013
     DIESEL FUEL ($/GAL)                    = .4500
     CONSTRUCTION COST INDEX                = 2.87
     LEVEL OF CONCENTRATION                 = 10000.
     PERCENT OF OWNERSHIP                   = 90.
     INTEREST RATE                          = .07
     TOTAL DYNAMIC HEAD (FT.)               = 30
     NUMBER OF UNITS OR CONTACTORS          = 1.0
     ONE WAY MILES                          = 20
     G-FACTOR                               = 150.
     VARIABLE INDICATOR                     = 00.
     WHICH UNIT (CTSGAL.OR.DOLYR)           = CTSGAL
     DETAIL OR SUMMARY OUTPUT               = SUMMARY
```

FIGURE B-3. INDEX.DAT data files set up for a summary formatted listing and a detail formatted listing.